PB-230 844

INDUSTRIAL WASTE SURVEY REPORT. GREAT WESTERN SUGAR COMPANY, STRAIGHT HOUSE BEET SUGAR FACTORY, WINDSOR, COLORADO, OCTOBER 10 TO DECEMBER 9, 1949

Graham Walton

Environmental Health Center
Cincinnati, Ohio

9 December 1949

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Straight House Beet Sugar Factory

Windsor, Colorado

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A Study of the Characteristics of the Individual and Combined Wastes from a Straight House Beet Sugar Factory and the Susceptibility of the Combined Factory Wastes to Treatment by Lagooning

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FEDERAL SECURITY AGENCY
Public Health Service
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By

Graham Walton
Sanitary Engineer

FEDERAL SECURITY AGENCY
Public Health Service
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WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY

Industrial Waste Survey Report

ABSTRACT

This survey was made to secure information for use in estimating the pollution due to wastes discharged from straight house beet sugar factories. Limited studies were also made of the treatment resulting when the combined factory waste was lagooned. For these purposes the characteristics of each of the major component wastes, and of the lagoon influents and effluents, were studied during the period of October through December, 1949.

In general, the Windsor Factory is typical of most straight house beet sugar factories in this area. The process by which the sugar was extracted and refined is described, and a detailed flow diagram is included.

In comparing the results of this study with data from other sources, or in using it to estimate the pollutional load from other factories, certain factors should be considered. The beets, which had an unusually high sugar content, were received in the factory in a relatively sound and unfrozen condition. Use of an older type diffusion battery which consisted of 14 cells, each of which was dumped through a side-gate at its bottom, required large quantities of wash water, and probably resulted in a relatively high BOD loading in this waste.

The principal wastes were the flume and beet washer wastes, the diffusion battery waste, the filter cake waste, and the pulp silo drainage. Data on the characteristics of each - except the beet washer waste - are given. Included are the volumes in gallons, the BOD in pounds, and the solids in pounds, per ton of beets processed. This information may be used to estimate the BOD loading in wastes discharged into natural waters from straight house factories comparable to the Windsor Factory.

VOLUMES, BIOCHEMICAL OXYGEN DEMAND
CONCENTRATIONS, AND POPULATION EQUIVALENTS
OF VARIOUS STRAIGHT HOUSE BEET SUGAR FACTORY WASTES

WASTE	VOLUME	B.O.D. 5-Day, 20°C	POPULATION EQUIVALENT(a)
	Gal. per ton of beets per day	ppm	Persons per ton of beets per day
Flume Water	1760	194	17.1
Beet Washer	485(b)	194(c)	4.7
Diffusion Battery	1420	510	33.1
Filter Cake	46	10,880	25.7
Pulp Silo Drainage	220	6,010	24.1
Total	3,931		154.7

(a) Based on 0.167 pounds of 5-day, 20°C. BOD per capita per day.
(b) Volume estimated.
(c) BOD estimated to be same as that of Flume Water.

Limited studies were made on the treatment effected by lagooning the combined factory waste, which included all factory wastes except the filter cake waste and that portion of the diffusion battery waste used to flush the ash pit. In passing through the main lagoon - a large, irregular lagoon providing an estimated 3 to 5 days storage - the reductions in BOD and suspended solids of the waste were 91.6 and 98.6 per cent respectively.

Results for the experimental lagoon studies on unscreened and screened (1/32" X 9/32" s.s.) combined factory waste are as follows:

	Lagoon No. 1 Unscreened Waste	Lagoon No. 2 Screened Waste
B.O.D. Reduction (%)	89.5	15.1
Suspended Solids Reduction (%)	96.1	96.9

These lagoons provided a theoretical detention time of approximately 2 days.

Studies were also started on lagooning of wastes screened through a coarse screen (5/32" X 5/8" c c), but were discontinued when this screen proved ineffective in removing such solid matter as the spent cossettes.

The studies to determine the effect of adding nitrate and phosphate to the waste prior to lagooning were cut short due to cold weather. The increasing effectiveness of those lagoons which received the nitrate and phosphate treated wastes, as compared with that of the lagoon which received the untreated waste, was encouraging, but the results must be considered to be inconclusive.

GENERAL INFORMATION

This report covers the study of straight house beet sugar factory wastes conducted at the Windsor Factory of the Great Western Sugar Company located at Windsor, Colorado.

1. Organization of Survey

This survey has been a cooperative project conducted by the Great Western Sugar Company and the Environmental Health Center of the U. S. Public Health Service. The Colorado State Game and Fish Department assisted by providing a sampler and the U. S. Bureau of Reclamation furnished a car for transportation.

At various times, both prior to its undertaking and during the period of this study, technical personnel of the organizations concerned held conferences to plan its course.

2. Dates of Survey

The field survey extended from October 10 through December 9, 1949. The individual and combined factory wastes were studied during three separate periods - starting October 11, October 31, and November 14 - each of which included 4 or 5 days of sampling. Special studies involving the treatment effected by lagooning the combined factory waste were divided into three periods, starting October 13, October 22, and November 20.

3. Personnel Participating

The following personnel cooperated or participated in this study:

GREAT WESTERN SUGAR COMPANY

Denver Office

A. A. Clark, Vice President and General Superintendent
C. E. Hirsch, Chief Engineer
E. H. Hungerford, General Chemist
A. R. Rees, Superintendent, Research Laboratory
C. H. Criswell, District Superintendent

Windsor Factory

A. M. Watson, Manager
M. Schmode, Plant Superintendent
J. R. Goodner, Master Mechanic
C. H. McCurry, Chief Chemist
W. S. Hart, Sampler

PUBLIC HEALTH SERVICE

Environmental Health Center

H. H. Black, Chief, Industrial Wastes Section
C. T. Carnahan, Engineer in Charge, South Platte River Basin Water Pollution Investigation
Graham Walton, Project Engineer
J. M. Cohen, Project Chemist
William Bjorklund, Technical Aid
Douglas Stevenson, Sampler *

* Employed by the Colorado State Game and Fish Department

4. Purpose

This survey was made to secure information which will enable the estimation of the pollution and particularly the BOD loadings of wastes discharged from straight house beet sugar factories using equipment and processes comparable to those used at the Windsor Factory, also to study the treatment effected by lagooning such wastes.

5. Location of Factory

The Windsor Factory of the Great Western Sugar Company is located on State Highway No.257 at the eastern outskirts of Windsor, Colorado.

6. Raw Materials

The principal raw material was the sugar beets. Other materials, which were used, included: coal for generating heat and power; coke and limestone for producing carbon dioxide; limestone for making lime; sulfur for producing sulfur dioxide; and water.

7. Products

The Windsor Factory produced granulated white sugar. By-products included molasses, which was shipped to one of the Company's Steffens house plants, and the spent beet pulp, which was stored in a large open silo and eventually sold to farmers as feed for cattle.

8. Operations

Operation is seasonal. The 1949 campaign commenced October 7 and continued through December 21. The rated capacity of this factory was 1,640 tons of beets per day. The actual tonnage sliced on the days of sampling the factory wastes varied between 1,530 and 1,684, and averaged 1,620 tons per day. The beets sliced in the 8-hour shift during which the samples were collected averaged 542 tons, and ranged from 524 to 565 tons. (This is equivalent to an average of 1,626, and a range from 1,572 to 1,695 tons per day).

9. Employees

The factory employed 186 persons, including 3 office employees. This was slightly under the 192 employees allowed under the allotment plan of the Great Western Sugar Company.

10. Water Supply

Water was obtained from two sources. That for drinking, extraction of sugar from the cossettes, and other limited uses was obtained from the Greeley Municipal Water Supply. All other water, such as that used for fluming and washing the beets, washing the diffusion cells, etc., was drawn from an irrigation ditch of the Kern Reservoir and Ditch Company.

11. Wastes

The filter cake waste and ash pit drainage were discharged through separate sewer systems to their respective lagoons. All other wastes - the flume water and beet washer wastes, the screened diffusion battery waste, pulp silo drainage, settled grate drippings, wash water, and the roof and surface drainage - were discharged through one or more sewers into the irrigation ditch of the Kern Reservoir and Ditch Company.

12. Sanitary Sewage

The sanitary sewage was discharged through a separate sewer into the above mentioned irrigation ditch.

13. Waste Treatment and By-Product Recovery

a. Diffusion Battery Waste - The diffusion battery waste was screened to recover the spent pulp prior to being discharged into the sewer.

b. Beet Washer Waste - The roller picking table spray wash was screened to remove the tailings before being discharged into the sewer.

c. Filter Cake Waste - The filter cake waste was pumped to a lagoon approximately 375 feet long by 75 feet wide. During the campaign a weir was installed to permit this lagoon to overflow into a sewer leading to the irrigation ditch when the depth became about 4 feet. Such overflow first occurred on Saturday, November 26.

d. Grate Drippings - The grate drippings flowed through a settling tank, used to recover the fine coal. The tank overflow was discharged to the irrigation ditch.

e. Ash Pit Drainage - Part of the screened diffusion battery waste was used to flush ashes from the ash pit. This waste was discharged to a separate retention lagoon.

The other wastes were all discharged without any treatment. Except for the filter cake waste and the ash pit drainage which were lagooned, all wastes were discharged into the Kern Reservoir and Ditch Company's irrigation ditch and normally flowed through a large lagoon, providing not more than a few days detention prior to overflowing into the Cache La Poudre River.

DISCUSSION OF THE PROCESS

The Windsor factory was built by the Great Western Sugar Company in 1903. It is one of 17 factories owned and operated by that Company. Except for the construction of a new power plant, sugar silos, and the addition of an intermediate 8 "high raw" pan, the equipment was essentially the same as in 1905. There had been only minor changes in the processing equipment and its operation.

Harvest of beets for the 1949 campaign at this factory commenced around October 1, and was practically completed by November 10. The harvested beets were either temporarily stored in piles at field stations or transported directly to the factory. In general, the yield per acre was high and the sugar content, which averaged 16.8%, was the best on record. Weather conditions were favorable and the beets as received at the factory were relatively sound and unfrozen.

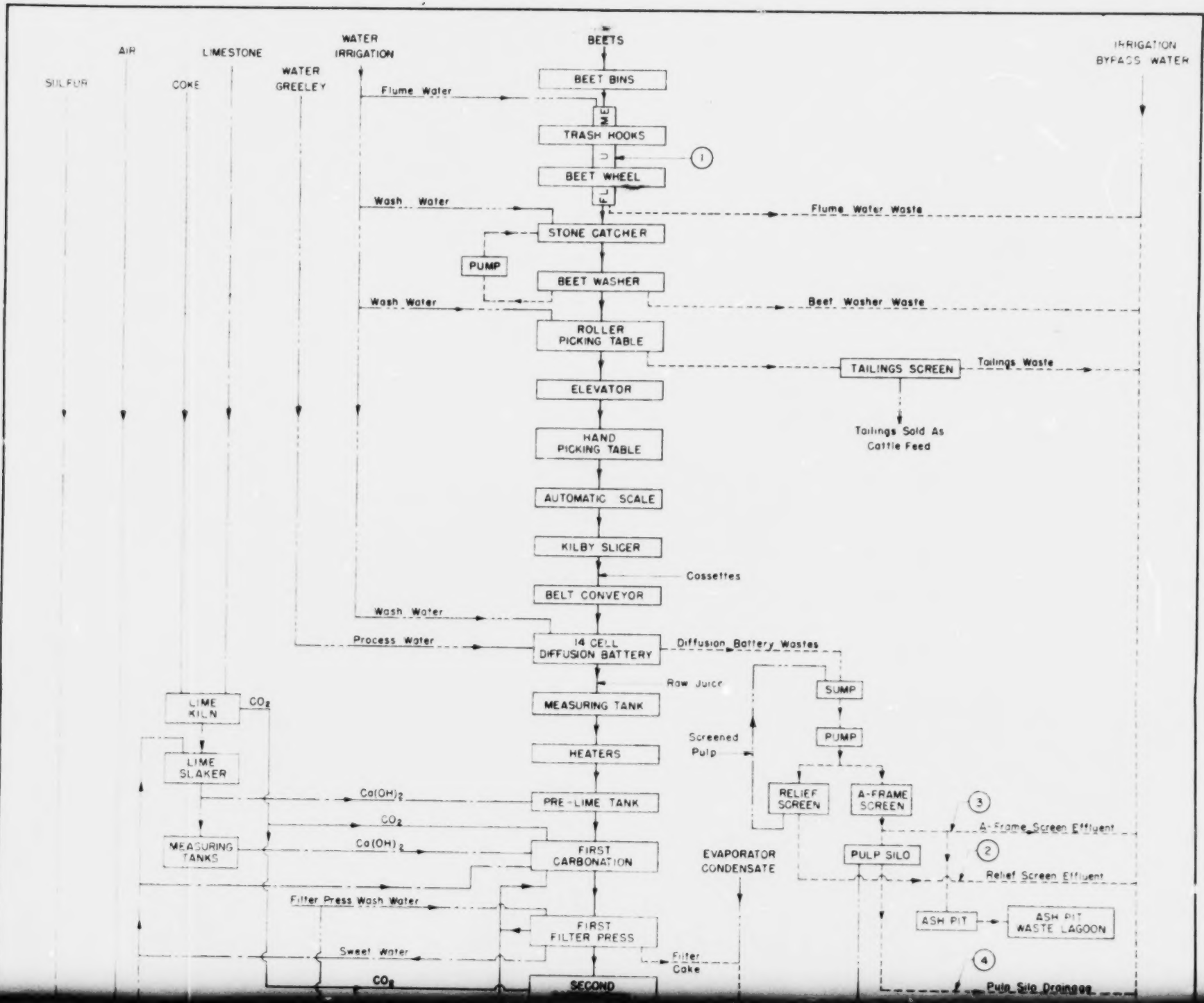
14. Manufacturing Process

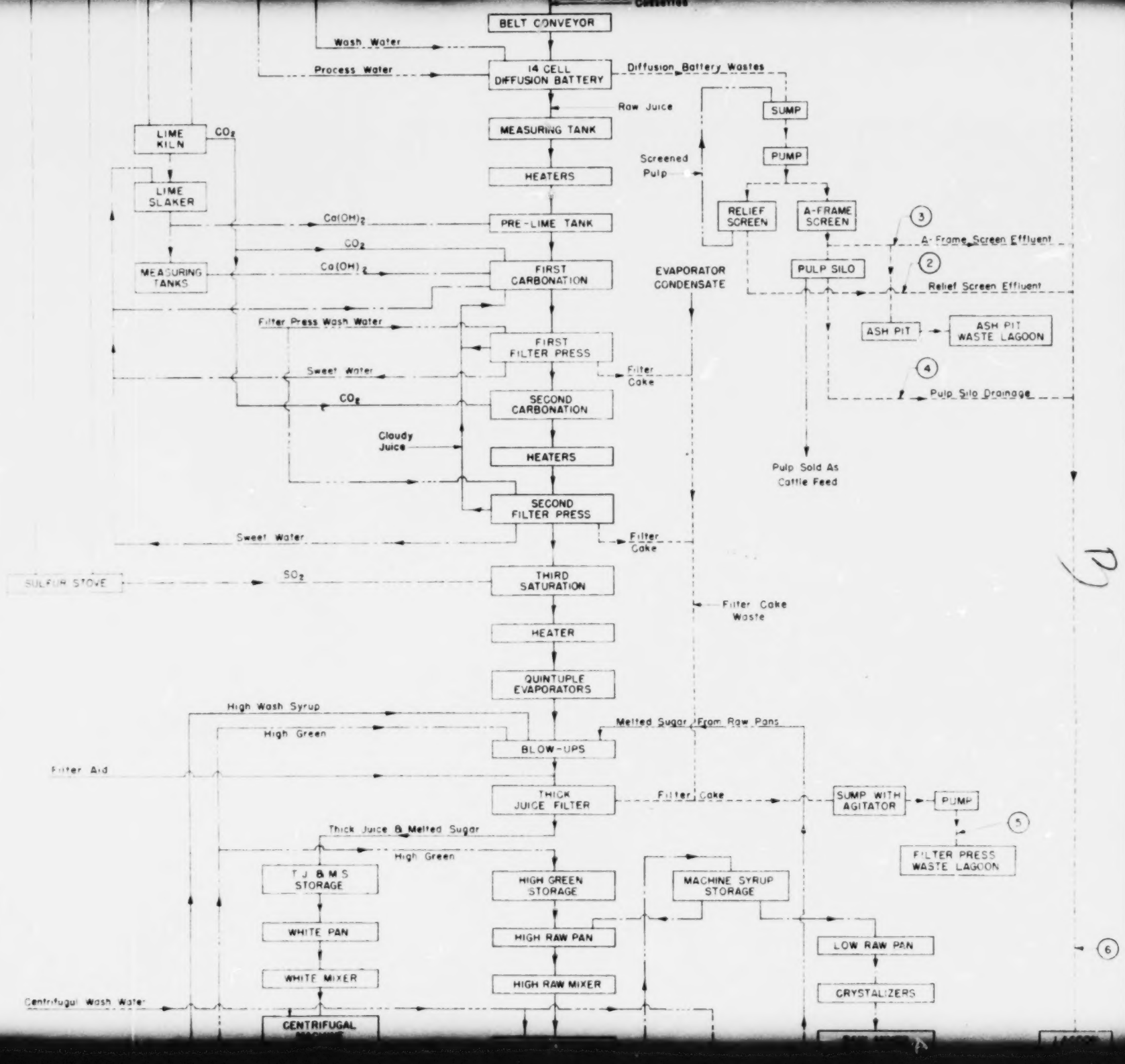
The beets were delivered to the yard where they were stored in piles adjacent to or in bins over flumes leading into a header flume extending into the factory. As needed, the beets were discharged into a flume to float or roll into the factory. En route they passed trash hooks which consisted of several hook-like rakes suspended on endless chains. These rakes dipped into the water and in moving upstream picked up beet tops, weeds, etc. This material was sold as cattle feed. Finally, the beets passed regulator gates which controlled the rate at which they were fed to the factory process.

The flume terminated at the beet wheel (see Flow Diagram, Fig. 1) which lifted the beets from the flume and elevated them to the washer. The flume water, which had been used to transport the beets and to remove most of the dirt, flowed through screens to the beet wheel and thence into the sewer.

The beets passed through a stone catcher and into the washer. Here the beets were agitated in clean water by revolving, slant paddles. This freed them of most of any remaining dirt or debris. From the washer the beets passed through a final spray wash as they moved along the roller table to the elevator. The spray was flowed between the rollers, through an A-frame screen, and thence into the sewer.

The elevator lifted the beets to the top of the building where they passed over a picking table. They were then discharged into an automatic weighing scale which dumped them into the fifty sliders.


BEETS
WATER IRRIGATION
AIR
LIMESTONE
WATER GREELEY
SULFUR
COKE
IRRIGATION BYPASS WATER
Flume Water
BEET BINS
TRASH HOOKS
BEET WHEEL
Wash Water
Flume Water Waste
STONE CATCHER
PUMP
BEET WASHER
Wash Water
Beet Washer Waste
ROLLER PICKING TABLE
TAILINGS SCREEN
Tailings Waste
Tailings Sold As Cattle Feed
ELEVATOR
HAND PICKING TABLE
AUTOMATIC SCALE
KILBY SLICER
Cossettes
BELT CONVEYOR
Wash Water
Process Water
14 CELL DIFFUSION BATTERY
Diffusion Battery Wastes
Raw Juice
MEASURING TANK
HEATERS
LIME KILN
CO_2
LIME SLAKER
$Ca(OH)_2$
PRE-LIME TANK
CO_2
MEASURING TANKS
$Ca(OH)_2$
FIRST CARBONATION
Filter Press Wash Water
FIRST FILTER PRESS
Sweet Water
Filter Cake
CO_2
SECOND
SUMP
Screened Pulp
PUMP
RELIEF SCREEN
A-FRAME SCREEN
EVAPORATOR CONDENSATE
PULP SILO
A-Frame Screen Effluent
Relief Screen Effluent
ASH PIT
ASH PIT WASTE LAGOON
Pulp Silo Drainage
1
2
3
4


BELT CONVEYOR
Wash Water
Process Water
14 CELL DIFFUSION BATTERY
Diffusion Battery Wastes
Raw Juice
MEASURING TANK
HEATERS
PRE-LIME TANK
FIRST CARBONATION
FIRST FILTER PRESS
SECOND CARBONATION
HEATERS
SECOND FILTER PRESS
THIRD SATURATION
HEATER
QUINTUPLE EVAPORATORS
BLOW-UPS
THICK JUICE FILTER
T.J. & M.S. STORAGE
HIGH GREEN STORAGE
MACHINE SYRUP STORAGE
WHITE PAN
HIGH RAW PAN
LOW RAW PAN
WHITE MIXER
HIGH RAW MIXER
CRYSTALIZERS
CENTRIFUGAL
LIME KILN
CO_2
LIME SLAKER
$Ca(OH)_2$
MEASURING TANKS
Filter Press Wash Water
Sweet Water
Filter Cake
Cloudy Juice
SULFUR STOVE
SO_2
Sweet Water
Filter Cake
Filter Cake Waste
High Wash Syrup
High Green
Melted Sugar From Raw Pans
Filter Aid
Filter Cake
SUMP WITH AGITATOR
PUMP
FILTER PRESS WASH WASTE LAGOON
Thick Juice & Melted Sugar
High Green
Centrifugal Wash Water
SUMP
PUMP
Screened Pulp
RELIEF SCREEN
A-FRAME SCREEN
EVAPORATOR CONDENSATE
PULP SILO
Pulp Sold As Cattle Feed
A-Frame Screen Effluent
Relief Screen Effluent
ASH PIT
ASH PIT WASTE LAGOON
Pulp Silo Drainage
1
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3
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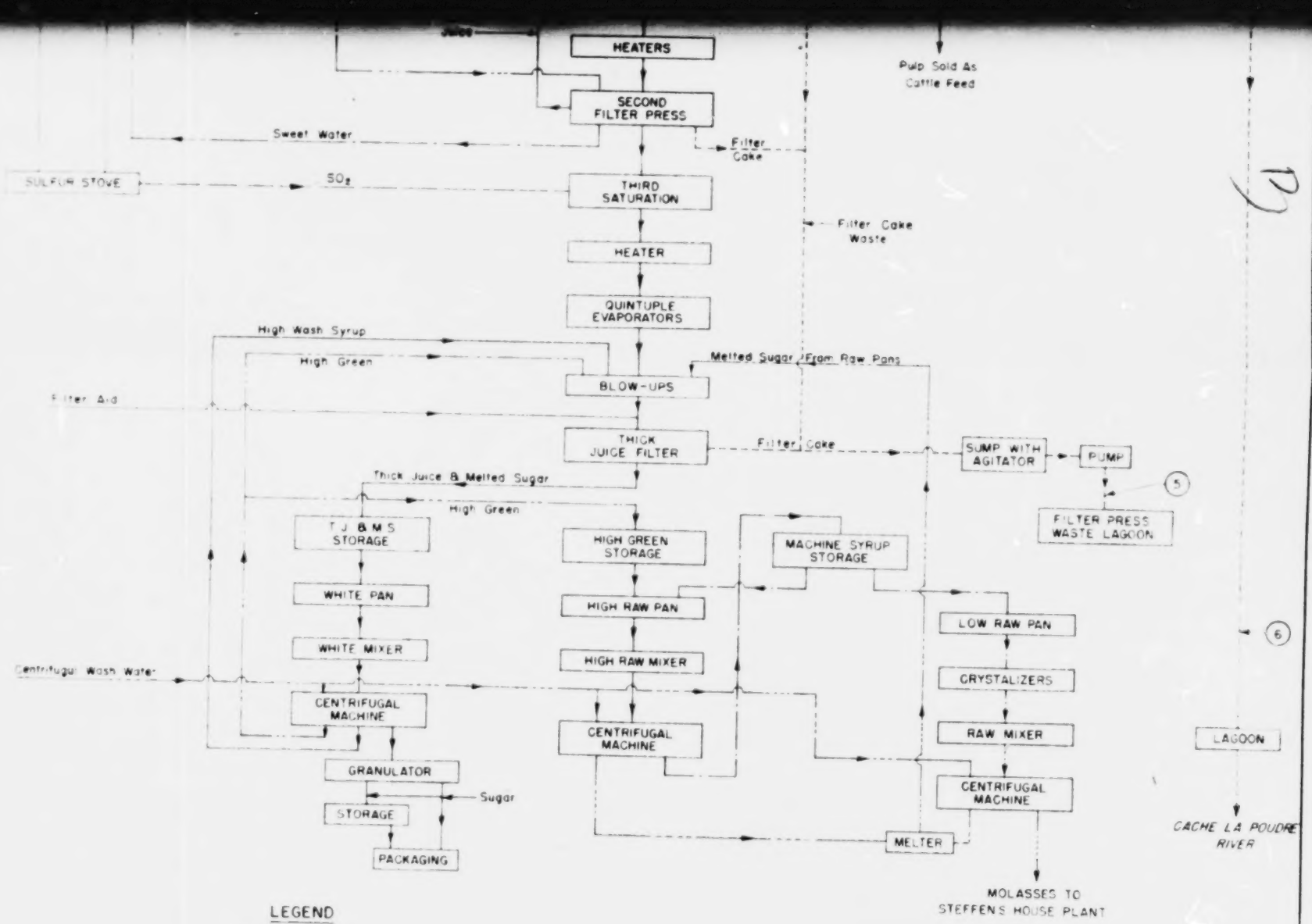
6



LEGEND

SAMPLING POINTS

1. Flume Water Waste
2. Diffusion Battery Waste, Relief Screen Effluent
3. Diffusion Battery Waste, A Frame Screen Effluent
4. Filter Cake Waste
5. Pulp Silo Drainage
6. Combined Factory Waste

FIGURE 1

FLOW DIAGRAM

WINDSOR BEET SUGAR FACTORY
GREAT WESTERN SUGAR COMPANY
WINDSOR, COLORADO

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO OCTOBER, 1949

In the Kilby slicers V-shaped knives rotating in a horizontal plane cut the beets into small, noodle-like strips, called "cossettes" or "noodles." From the slicers the "cossettes" were discharged onto a belt conveyor from which they were directed into any one of the diffusion cells.

The diffusion battery consisted of 14 cylindrical cells connected in series. Each cell was charged with cossettes through a removable cover, and the spent pulp and wash water were discharged through a side-dump gate at the bottom. Sugar was extracted by passing hot water, the temperature of which was gradually increased to a maximum of between 80 and 85°C., through the cells. The counter flow principle was used; the fresh water entered the cell containing those cossettes the sugar from which had been most completely extracted, and the raw juice, or most concentrated sugar water, was drawn from the cell which had been just placed under diffusion. When diffusion was considered complete, the spent pulp was dumped and the cell cleaned by flushing and hosing. It was then recharged with cossettes and again entered into the circulatory system.

The raw juice was measured and sent through heaters to the pre-lime tank, where milk of lime was added. It then flowed to the first carbonation tank. Here more milk of lime was added, then the mixture was treated with carbon dioxide gas until most of the calcium hydroxide had been precipitated as calcium carbonate. After carbonation to the desired point, the mixture was sent to the first filter presses, where the first lime cake - the calcium carbonate and impurities contained therein - was removed. The partially purified juice was then pumped to second carbonation, where most of the remaining lime was precipitated with carbon dioxide. This juice then passed through a heater to the second filter press, where the second lime cake was removed. The second press filtrate was sent to the third saturation, where it was treated with sulfur dioxide gas.

The purified or thin juice, which contained from 10-13% sugar, was heated before entering the quintuple evaporators where it was concentrated to a syrup containing about 60% sugar. This concentrated or evaporated thick juice, together with the melted sugar, the high wash and the high green syrup, went to the "blow ups" which were mixing and heating tanks. Filter aid, a diatomaceous earth, was added and the resulting mixture filtered in the thick juice filters. This filtered thick juice was drawn into the white vacuum pan, where it was evaporated to that concentration which on crystallization gave the desired granular size. The mass of crystals and the surrounding liquor is called the "white massecuite." From the white pan the massecuite was discharged to the centrifugals which were basket-like screens which revolved at high speed. The granulated sugar was retained on the screens through which the mother liquor or high green flowed. Since some of the impure

syrup remains on the crystals, they were finally washed with a fine spray of hot water. The resulting syrup was called the "high wash."

The washed sugar was dried in the granulator and bucked or sent to storage, while the high wash was returned to the blow ups and the high green went to the intermediate pan or was sent back to the blow ups.

The high green which was [illegible] the high raw pan was treated by a similar process. The resulting impure sugar went to the melter and thence back to the blow ups, and the mother liquor or machine syrup was crystallized in either the high or low raw pans. Sugar from the low raw pan entered the melter and was then returned to the blow ups, and the mother liquor or low green was shipped to one of the Company's Steffens house plants for further treatment to recover sugar.

The final product was white granulated sugar of nearly 100% purity. More or less typical analyses of which show the following foreign substances: moisture 0.02%; mineral ash, 0.009%; sulfates, less than 5 ppm, organic non-sugars, trace.

Two by-products were recovered. These were the spent pulp and other screenings which are sold as cattle feed; and the low green or molasses which was shipped to one of the Steffens house factories.

15. Wastes

Since the sugar beet is the principal source of the organic matter in the wastes, its composition is of interest. According to Hallwart (1)(a), the principal constituents of the sugar beet root were:

Constituent	Per Cent
Water	75 to 80
Sucrose	9 to 18
Cellulose))	0.8 to 2.5
Lignin)	
Nitrogenous matter, protein and amino	0.6 to 2.0
Pabs	0.2 to 0.5
Potassium and other mineral salts	0.3 to 2.0

(a) Numbers in parentheses refer to references in bibliography.

Other substances which are present in small amounts are: glucose, raffinose, organic acids (oxalic, tartaric, citric, malonic, succinic, and gluconic), amines and amino compounds (leucine, asparagin, betaine and tyrosine), gums, pectic matters and coniferin. These and other substances such as lime and sulfur, undoubtedly occur in varying concentrations in the factory wastes.

a. Condenser Water - The condenser water included the condensed steam and vapors from the steam turbine, heat exchangers, the evaporators and the several pans. Since at this factory all condenser water was used for flume and process water, boiler feed, transportation of filter cake and other purposes, it has not been considered a waste. In fact, it was usually used wherever a relatively pure water was desired.

b. Flume Water Waste - The flume water was composed of condenser and irrigation water. In transporting the beets from the storage bins to the beet wheel it became laden with considerable quantities of mud, sand and debris. The amount of such matter has been reported to vary with the soil condition (wet or dry) and the method (hand or machine) under which the beets are harvested. Stones, weeds, beet tops and other foreign material were present in relatively small quantities. The strength of this waste has been reported to vary with the percentages of beets which are imperfect, broken or damaged by frost.

c. Beet Washer Waste - The beet washer waste resulted from the mechanical agitation of beets and water in the washing tank, and from the high pressure spray directed onto the beets as they moved along the roller table. The latter was screened to remove the tailings which were sold as cattle feed.

d. Diffusion Battery Waste - The waste from the multiple-celled diffusion battery consisted of the residual water and spent cossettes in the cells when removed from the diffusion process, plus the water used in hosing and cleaning the cells. This water was screened to remove the spent cossettes prior to discharge to the sewer. It contained considerable amounts of dissolved organic matter (e.g. the sucrose sugar content as computed from analyses reported by the factory was [illegible] ppm).

Fig. 2. Farmers loading spent beet pulp which they use for cattle feed.

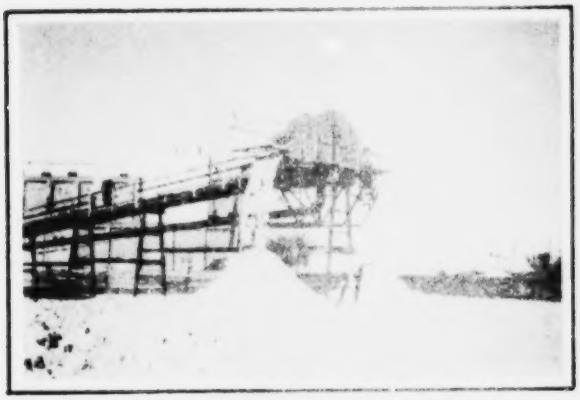


Fig. 3. The spent pulp was removed from the diffusion battery waste by an A-frame screen and discharged into the pulp silo.

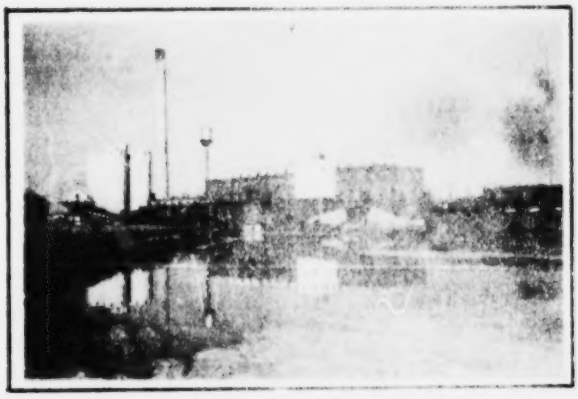


Fig. 4. A view of the filter cake waste lagoon showing the pulp silo on the left and the beet bins on the right.

e. Pulp Silo Drainage - The pulp silo drainage was the waste which collected in and drained through the underdrainage system of the large open silo in which the spent cossettes were received and stored until removed for use as feed for cattle. The liquid portion of this waste originated from the diffusion battery waste which failed to pass the A-frame screen, also from rain or other precipitation.

f. Filter Cake Waste - The filter cake waste was the slurry resulting from the addition of water to enable water-carriage of the lime and other cake removed by the filters which followed the carbonation and sulfonation treatments. This water-borne cake contained calcium carbonate, calcium sulfate and filter aid, together with the impurities removed from the raw and thick juices.

g. Combined Factory Waste - The combined factory wastes included the flume water and beet washer wastes, screened diffusion battery waste, pulp silo drainage, settled grate drippings, floor washings, roof and surface drainage, and sanitary sewage, together with a small amount of irrigation water. Not included were the filter cake waste and the small amount of diffusion battery waste used to flush the ashes from the ash pit.

SURVEY PROCEDURES

16. Sample Collection and Compositing

For the purpose of determining the characteristics of the factory wastes samples were collected of the flume water waste; diffusion battery - both main and relief screen effluents - waste, filter cake waste, pulp silo drainage, and the combined factory waste. Samples taken in connection with the lagoon studies were the influent and effluent from each lagoon. All samples were collected and composited by an employee of the factory during the 8-hour shift commencing at 8:00 A.M.

Every reasonable precaution was taken to insure the collection of representative portions of the various wastes. In the case of the filter cake waste and pulp silo drainage the composited samples consisted of eight individual portions, the volumes of which were adjusted according to the flow of the waste at the time of sampling. Each of the other composite samples consisted of eight 1-quart portions. These individual portions were collected at approximately hourly intervals. Immediately after collection each portion was poured into the 3-gallon carboy used for compositing that sample. All carboys, except that for the filter cake waste, were set in a box and packed in ice. Several temperature readings, taken immediately following the collection of the final portion and after thorough mixing, indicated the temperature of the composited samples to be between 10 and 15°C. It was considered unnecessary to ice the filter cake waste because of its high lime content.

At the end of the sampling period each carboy containing a sample was thoroughly shaken and immediately inverted to fill a 2-quart jar, and in some cases also a 1-quart jar. The former were packed in ice for transportation and until the following morning when removed for analyses at the Environmental Health Center Field Laboratory at Greeley. The 1-quart samples were taken to the Great Western Sugar Company's Laboratory at Brighton immediately following the completion of the sampling.

17. Flow Measurement

The determination of the relative pollution due to the various factory wastes requires data on the volume as well as the strength of each waste. Thus, wherever considered necessary and practical a weir or Parshall flume was installed to measure the discharge of each waste. In general, the heads on these weirs or flumes were indicated by a staff gage, readings of which were taken at approximately hourly intervals during the 8-hour sampling period. Because of difficulties involved in their measurement, the volumes of flume water and beet washer wastes are those estimated by the technical staff at the factory.

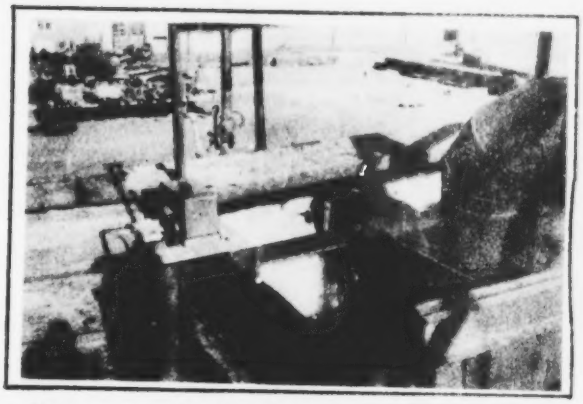


Fig. 5. The 18-inch rectangular weir and continuous water level recorder as installed to measure the screened diffusion battery waste.

Fig. 6. The 3-inch Parshall flume as installed for measuring the pulp silo drainage.

Fig. 7. Looking upstream at the 24-inch Parshall flume used to measure the combined factory waste.

Pertinent data on flow measurement devices and their probable accuracy are given in Table 1. Factors considered in estimating the probable accuracy of the flow data were the condition - particularly the weir crest - of the device, the probable error in head measurement, the effect of abnormal velocity of approach, and the fluctuations in the flow. All weir crests were carefully checked by means of an engineer's transit [illegible] and in most cases rechecked by using a carpenter's square and level. In general, the errors in head readings were considered to be not greater than 0.01 foot.

Although there may be considerable error in the individual daily flow data, the summation of the average daily gallons per ton of beets processed for each waste checks exceedingly well with corrected volume for the combined factory waste (see table 3).

18. Laboratory Procedure

The following analytical results are reported for samples collected during this survey:

Temperature
pH
Alkalinity, total and phenolphthalein
Acidity
Biochemical Oxygen Demand (BOD)
Total solids as total, suspended, and filtrable
Volatile solids as total, suspended, and filtrable
Nitrogen as organic, ammonia, nitrite and nitrate nitrogen
Phosphorus

Total and total fixed solids, and suspended total and fixed solids, were actually determined; all other results on solids were computed therefrom. The organic nitrogen concentrations were obtained by the difference between the total and ammonia nitrogen values.

In general, the analytical procedures employed are those given in "Standard Methods for the Examination of Water and Sewage," 9th Edition, 1946 (5).

TABLE 1 - FLOW MEASUREMENTS AND THEIR PROBABLE ACCURACY

WASTE	MEASURING DEVICE	FORMULA	REMARKS	PROBABLE ACCURACY
Flume Water	None		Flow as estimated by technical personnel of factory.	?
Beet Washer	None		Flow as estimated by technical personnel of factory.	?
Diffusion Battery (1) Main Screen Effluent	18" end contracted rectangular weir and continuous water level recorder	Cone (2) $Q=3.247LH^{1.48}-\left(\frac{0.56/L}{1/2L}\right)^{1.6}H^{1.9}$	Flow extremely variable; velocity of approach turbulent; crest not sharp; end contractions inadequate; head variable, from 0.0 to 1.0 feet.	± 15%
(2) Relief Screen Effluent	90° V-Notch weir and staff gage	King (3) $Q=2.52H^{2.47}$	Flow reasonably steady; velocity of approach turbulent through October 14, but much improved by installation of a baffle on that date; crest in fair condition; foam gave some difficulty in reading head; heads around 0.70 feet.	± 10% through Oct.14 ± 5% thereafter
Filter Cake	3" Parshall flume and staff gage	Parshall (4) $Q=0.992H^{1.547}$	Flow extremely variable; velocity of approach extremely turbulent at higher flows; heads from 0.20 to 0.40 feet.	± 20%
Pulp Silo Drainage	3" Parshall flume and staff gage	Parshall (4) $Q=0.992H^{1.547}$	Flow reasonably steady; velocity of approach conditions excellent; head around 0.70 feet.	± 3%
Combined Factory	24" Parshall flume and staff gage	Parshall (4) $Q=8H^{1.522W^{0.026}}$	Flow reasonably steady; velocity of approach condition good; heads around 1.10 feet	± 3%
By-pass Irrigation Water	42" suppressed weir and staff gage	King (3) $Q=3.34H^{1.47}$	Flow reasonably steady; velocity of approach condition good; 2" wide plank crest; heads very low, averaging around 0.15 feet.	± 20%
Main Lagoon Effluent	37½" Suppressed weir and staff gage	King (3) $Q=3.34H^{1.47}$	Flow steady; velocity of approach conditions good; 2" wide plank crest, heads around 0.60 feet.	± 10%

TABLE 1 - FLOW MEASUREMENTS AND THEIR PROBABLE ACCURACY (Cont'd)

WASTE	MEASURING DEVICE	FORMULA	REMARKS	PROBABLE ACCURACY
Lagoon No.1 Influent	90° V-notch weir and staff gage	King (3) $Q=2.52H^{2.47}$	Flow steady; velocity of approach conditions fair; crest not sharp-edged; heads controlled at 0.50 feet.	± 10% through Nov.8
			Prior to the studies starting Nov.20, a sharp-edged weir was installed; after Nov.22, the flow was reduced to 0.3 cfs; velocity of approach condition good; head controlled at 0.36 feet.	± 3%
Lagoon No.2 Influent	6" Parshall flume and staff gage	Parshall (4) $Q=2.06H^{1.58}$	Flow steady, velocity of approach conditions fair; heads controlled at 0.41 feet.	± 5%
	90° V-notch weir and staff gage	King (3) $Q=2.52H^{2.47}$	Used starting November 20. Flow steady, crest sharp-edged; velocity of approach condition fair; heads controlled at 0.36 feet.	± 5%
Lagoon No.3 Influent	90° V-notch weir and staff gage	King (3) $Q=2.52H^{2.47}$	Flow steady; crest sharp-edged; velocity of approach conditions fair; head controlled at 0.36 feet.	± 5%
Effluents from all lagoons	90° V-notch weirs and staff gages	King (3) $Q=2.52H^{2.47}$	Flow reasonably steady; crest rounded; velocity of approach conditions good; heads variable.	± 10%

EXPLANATION OF ANALYTICAL DETERMINATIONS

A brief explanation of the various laboratory determinations is given below to aid in the interpretation of the analytical results reported.

19. Temperature

The reported average, maximum and minimum temperatures in °C. are those determined by temperature readings on each hourly portion of the sample.

20. pH

The symbol "pH" denotes the logarithm of the reciprocal of the hydrogen-ion concentration of the water, sewage or waste. It is a measure of the relative intensity of the acidity or alkalinity, and not of the amount of acid or alkali present. Solutions having a pH below 7.0 have acidity; those having a pH above 7.0, an alkalinity.

In each case the intensity changes very rapidly as the pH departs from the neutral value of 7.0.

The pH may be significant for the detection of an abnormal discharge into a given waste, also for its influence on biological decomposition and chemical treatment processes. As regards the pollution of natural waters, extreme ranges of pH may affect aquatic life and increase costs of treatment of a water used for domestic or industrial purposes.

21. Alkalinity

The alkalinity of a water or waste represents its content of carbonates, bicarbonates and hydroxides; and, although rarely present in significant quantities, of borates, silicates and phosphates of the alkali and alkali earth metals. The calcium and magnesium alkalis or salts usually account for most of the alkalinity.

In the titration with the standard acid two end-points are sometimes used. The first, or phenolphthalein end-point, measures the hydroxides plus one-half the normal carbonates; the second, or methyl orange end-point, corresponds to the total alkalinity. In each case the alkalinity is expressed in terms of the equivalent parts per million (ppm) of calcium carbonate ($CaCO_3$).

The discharge of a highly alkaline waste into a natural water course may be of concern when such water is used as a source for domestic or industrial water supplies, and in extreme cases where the water is used for irrigation.

22. Acidity

The acidity of a water or waste represents the content of free carbon dioxide, mineral and organic acids, and those acid salts which hydrolize to give hydrogen ions. It is expressed in terms of the parts per million of calcium carbonate ($CaCO_3$), equivalent to the acid neutralized on titration with a strong alkali to the phenolphthalein end-point.

23. Biochemical Oxygen Demand (BOD)

The biochemical oxygen demand (BOD) of a sewage, sewage plant effluent, polluted water, or an indistrial waste is the oxygen required during stabilization of the organic matter undergoing aerobic biological decomposition. The time and temperature values generally used for this analysis are 5 days and 20°C. Approximately 68% of the ultimate BOD of a normal domestic sewage is satisfied on incubation for 5 days at 20°C. However, this ratio of 5-day to ultimate BOD does not necessarily hold for industrial waste. In such cases the rate of oxygen utilization may be affected by the carbon-nitrogen ratio, the presence of substances inhibiting biological decomposition, or other factors.

The BOD determination is significant as a measure of the relative strength of the sewage, sewage plant effluent, river water or of certain industrial wastes. It also indicates the possible extent and duration of oxygen depletion of the receiving water. Depletion of oxygen in natural waters may destroy fish and other aquatic life, or result in the production of obnoxious odors.

24. Population Equivalent

Normal domestic sewage, relatively free from industrial wastes, possesses characteristics which are reasonably well defined. It is therefore possible to compare sewages on a common basis. Industrial wastes, however, vary greatly according to the nature of the industry and the particular processes employed. They have no well defined characteristics.

Thus, the "Population Equivalent" has been used to compare the BOD load of each of the various wastes with that of a normal domestic sewage, reasonably free from industrial wastes. In this report the population equivalent has been based on 0.167 pounds of 5-day, 20°C. BOD per capita per day (6), which was the value determined by averaging the results obtained for several domestic sewages, reasonably free from industrial wastes.

25. Solids

Solids are reported as total and volatile solids, with each of these being subdivided into total, suspended and filtrable - sometimes

referred to as "dissolved" - solids. The actual analyses included only the total and total fixed solids, and the suspended total and fixed solids; all other data reported were calculated therefrom.

Normally the volatile solids are considered to be organic material. However, in case of lime bearing wastes - the filter cake and combined factory wastes - the volatilization of carbon dioxide from the calcium carbonate results in high volatile solid values.

For domestic sewage the volatile and suspended solids data usually show a definite relation to BOD. However, this is seldom true for an industrial waste. The principal value of these determinations is that they indicate the amount of settleable material, both organic and inorganic, contained in the various wastes.

26. Organic Nitrogen

The organic nitrogen is reported in parts per million of nitrogen in the form of proteins and their decomposition products, amino acids, and other nitrogenous matter.

This determination indicates the relative strength of the waste, as concerns the decomposable nitrogenous matter.

27. Ammonia Nitrogen

Ammonia nitrogen is reported as the parts per million of nitrogen present in the form of ammonia (NH_3). Since ammonia is the first step in the breakdown of nitrogenous organic matter, the relative amount of ammonia present in a waste may be indicative of its freshness.

28. Nitrite Nitrogen

Nitrite nitrogen is reported as parts per million of nitrogen present in the form of soluble nitrites. Although this determination is generally used to indicate the first stage in the oxidation of organic nitrogenous matter, in this study it was used to indicate the reduction in nitrates in the nitrate treated and lagooned wastes.

29. Nitrate Nitrogen

Nitrate nitrogen is reported as parts per million of nitrogen present in the form of soluble nitrates. Nitrates are the final stage in the oxidation of nitrogenous matter. However, in this study the significance of this analysis lies in its providing a measure of the utilization of nitrates in the nitrate treated lagooned wastes.

30. Phosphorus

Phosphorus is reported as parts per million of soluble phosphorus. Biological oxidization of sewage and certain industrial wastes requires the presence of soluble phosphorus; for domestic sewage treated by the activated sludge process the phosphorus required is about 1/2 ppm per 100 ppm of BOD removed. This determination was used in this study to indicate the availability of phosphorus and its utilization by the biological processes active in the lagoons.

DISCUSSION OF RESULTS ON FACTORY WASTES

The average characteristics of straight house beet sugar factory wastes as determined by this study are shown in Table 2. Records of the daily flows and the analytical results for each sample collected may be found in Appendix A. In general, the analytical data are given in parts per million (ppm) by weight; however, an exception is that for filter cake waste which is reported in milligrams per liter (mg/l). This unit has been used because laboratory sampling was on a volumetric basis and the specific gravity of this waste was approximately 1.06.

31. Flume Water Waste

The flume water waste, as estimated by the technical staff at the factory, averaged 2,880,000 gpd, or 1,760 gallons per ton of beets processed. The average temperatures of the several samples collected varied between 26 and 28°C. The pH (7.6) and alkalinity (235 ppm) were within a normal range for natural waters in this area.

The 5-day, 20°C. BOD averaged 191 and varied from 151 to 241 ppm. Its strength was that of a normal domestic sewage. The BOD loading amounted to 2.85 pounds per ton of beets. This is low when compared to data for such waste as given by Eldridge (7) and as determined for the Loveland Factory (8).

The total suspended solids averaged 4,320 ppm, or about 63.5 pounds per ton of beets; and the total volatile solids were 800 ppm, 330 ppm of which were suspended. The average ammonia and organic nitrogen concentrations were 4.0 and 15.9 ppm, respectively.

32. Beet Washer Waste

Due to the difficulties involved in measuring the discharge and in securing representative samples, the beet washer waste was not sampled. The flow which included the spray wash from the roller table, was estimated at 720,000 gpd, or 485 gallons per ton of beets.

For the purposes of determining the relative BOD loadings of the various wastes, the BOD of this waste has been assumed to be the same as that for the flume water waste.

33. Diffusion Battery Waste

The screened wastes - relief and main screen effluents - from the 14 side-dump cells of the diffusion battery averaged 2,235,000 gpd, or 1,370 gallons per ton of beets processed. Inclusion of that amount of this waste diverted for water-carriage of ashes, increased this volume to 1,420 gallons per ton of beets

TABLE 2 – AVERAGE CHARACTERISTICS OF STRAIGHT HOUSE BEET SUGAR FACTORY WASTES – WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-NOVEMBER, 1949

Determination	Flume Water Waste	Diffusion Battery Waste (a)	Filter Cake Waste (b)	Pulp Silo Drainage	Combined Factory Waste (c)
Volume (gal. per ton of beets)	1760	1420 (d)	46	270	4060
Temperature (°C.)	27	34	23	32	25
pH	7.6	7.8	11.8	4.0	6.5
Alkalinity, Phenolphthalein (ppm as $CaCO_3$)	-	-	7160	-	-
Alkalinity, Total (ppm as $CaCO_3$)	235	160	57,400	3,000 (e)	227
B.O.D., 5-day, 20°C. (ppm)	194	510	10,880	6,010	652
Total Solids, Total (ppm)	5270	1990	117,400	4,810	3,660
Suspended (ppm)	4320	620	113,700	170	2,290
Filtrable (ppm)	990	1370	3,700	4,640	1,370
Volatile Solids, Total (ppm)	800	850	20,700	3,510	1,000
Suspended (ppm)	380	380	19,500	140	370
Filtrable (ppm)	420	470	1,200	3,370	630
Nitrogen, NH_3 (ppm)	4.0	5.5	5.7	3.0	3.4
Organic (ppm)	15.9	17.0	657	74	17.7

(a) Weighted results of analytical data for relief and main screen effluents.
(b) Analytical data for filter cake waste are reported in mg/l instead of ppm; to obtain ppm divide by the specific gravity = 1.06.
(c) Includes 485 gallons per ton of beet washer waste and 220 gallons per ton of irrigation water by-passing the factory, but does not include 46 gallons per ton of filter cake waste and the 50 gallons per ton of diffusion battery waste diverted to the ash pit lagoon.
(d) Includes 50 gallons per ton of diffusion battery waste diverted to ash pit lagoon.
(e) Acidity, result of a single determination.

The temperature averaged 34° C. and the pH (7.8) and alkalinity (160 ppm) were reasonably normal for natural waters in this area. The BOD for the relief screen effluent averaged 533 ppm; and that for the main screen effluent, 501 ppm. This gives a weighted average of 510 ppm, or 5.54 pounds of BOD per ton of beets. This is approximately the same loading as indicated by Eldridge (7).

The total suspended solids averaged 620 ppm, or about 7.4 pounds per ton of beets. The total volatile solids averaged 850 ppm, of which 45%, or 4.5 pounds per ton, were suspended.

The organic and ammonia nitrogen concentrations averaged 17.0 and 5.5 ppm, respectively.

3%. Filter Cake Waste

The average discharge of filter cake waste as determined by measurement in the Parshall flume was 74,700 gpd [a], or 46 gallons per ton of beets processed. The pH varied between 11.7 and 11.9 and the phenolphthalein and total alkalinities averaged 7,160 and 57,400 mg/l, respectively.

The BOD varied from 7,700 to 14,500 mg/l, averaging 10,780 mg/l. It amounts to 4.38 pounds per ton of beets, or 16.5% of the total BOD load from the factory. The total suspended solids concentration averaged 113,700 mg/l, or 43.3 pounds per ton of beets. The total volatile solids concentration was 20,700 mg/l, about 95% of which were suspended.

The average concentrations for organic and ammonia nitrogen were 457 and 5.7 mg/l, respectively. This waste was very high in organic nitrogenous matter.

35. Pulp Silo Drainage

The drainage from the pulp silo amounted to 439,000 gpd, or 270 gallons per ton of beets processed. The temperature averaged 32° C. The pH varied between 3.8 and 4.1, and the acidity, as indicated by a single determination, was 3,000 ppm.

The BOD varied from 3,400 to 8,250 ppm. It averaged 6,010 ppm and amounted to 12.37 pounds per ton of beets. Although this waste composed only 6.8% of the total waste discharged from the factory, it contributed 47.9% of the BOD pollutional load.

(a) According to factory records this flow averaged 547 tons or 124,000 gallons per day. This value was computed from the amount of CaO added and the average CaO concentration in the waste.

The suspended solids concentration was negligible, averaging only 168 ppm. Volatile solids averaged 3,510 ppm, better than 95% of which were filtrable. Organic and ammonia nitrogen concentrations averaged 74.4 and 3.0 ppm, respectively.

36. Combined Factory Waste

The combined factory waste included all liquid and liquid carried factory wastes except the filter cake waste (46 gpt) and that portion (50 gpt) of the screened diffusion battery waste used to flush the ash pit, together with irrigation ditch diluting water which amounted to about 320 gallons per ton of beets.

The average flow as measured by the 24-inch Parshall flume was 6,570,000 gpd, or 4,060 gallons per ton of beets. The temperature varied from 24 to 27° C.

The pH averaged 6.5 and the total alkalinity was only 227 ppm. The BOD varied from 473 to 1,026 and averaged 652 ppm. It amounted to 22.09 pounds and had a "Population Equivalent" of 132 people per ton of beets. The total BOD pollution from the factory was equivalent to normal domestic sewage from a city having a population of 210,000 people.

The total suspended solids averaged 2,290 ppm, or 77.5 pounds per ton of beets; and the total volatile solids, 1,000 ppm, 37% of which were suspended. The organic and ammonia nitrogen concentrations averaged 17.7 and 3.4 ppm, respectively.

37. Summary

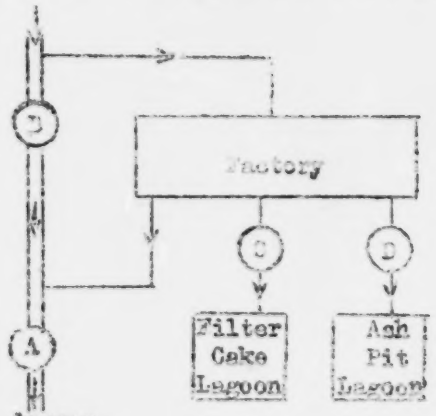
The average volumes and characteristics of various wastes from a straight house beet sugar factory are given in Table 2. Those of greatest volume were the flume water and diffusion battery wastes. The strongest, as indicated by BOD determinations, were the filter cake waste and pulp silo drainage. All except the screened diffusion battery wash and pulp silo drainage were high in total suspended solids. The pH and alkalinity of the lime bearing filter cake waste were high, while the pulp silo drainage was acid and had a low pH.

Of particular interest is Table 3 which gives for each waste its volume in gallons, and BOD in pounds, per ton of beets processed. It is particularly significant to note that the pulp silo drainage and filter cake waste, which amount to only 7.9% of the total volume, contributed 64.4% of the BOD load. Exclusion of these wastes from the receiving waters would be equivalent to substantial waste treatment.

Table 4 gives the solids, expressed in pounds per ton of beets processed for each waste. These data are significant in indicating the amount of silt and decomposable sludge in the wastes. The flume water and filter cake wastes contained a total of 127 pounds per ton of suspended solids. Lagoons receiving

TABLE 3 - AVERAGE OF DAILY VOLUMES, BIOCHEMICAL OXYGEN DEMAND LOADINGS AND POPULATION EQUIVALENTS OF STRAIGHT HOUSE BEET SUGAR FACTORY WASTES - WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-NOVEMBER, 1949

WASTE	VOLUME		B.O.D.		POPULATION (a) EQUIVALENT
	Gal. per ton of beets	% of Total	Lb. per ton of beets	% of Total	persons per ton of beets per day
Flume Water (b)	1760	44.2	2.85	11.0	17.1
Beet Washer	485	12.2	0.78	3.0	4.7
Diffusion Battery	1420 (c)	35.7	5.54	21.5	32.6
Filter Cake	46	1.1	4.28	16.6	25.7
Pulp Silo Drainage	270	6.8	12.37	47.9	74.1
Total	3981	100.0	25.82	100.0	154.2
Combined Factory, Uncorrected (A) (d)	4060		22.09		
Bypassed Irrigation Water (B)	-320		-0.00		
	3740		22.09		
Filter Cake Retained in Lagoon (C)	+ 46		+ 4.29		
Diffusion Battery Retained in Ash Pit Lagoon (D)	+ 50		+ 0.18		
Combined Factory - Corrected	3836		26.55		



(a) Based on 5-day, 20°C. B.O.D. of 0.167 lb./capita/day.
(b) B.O.D. assumed to be that of flume water waste, or 194 ppm.
(c) Includes 50 gallons per ton of diffusion battery waste used to transport ashes to lagoon.
(d) See sketch, includes 320 gallons per ton of bypassed irrigation water, but does not include filter cake waste (46 gallons per ton) or the 50 gallon per ton of diffusion battery waste used to flush ashes from ash pit to lagoon.

TABLE 4 - AVERAGE TOTAL AND VOLATILE SOLIDS LOADINGS OF STRAIGHT HOUSE BEET SUGAR FACTORY WASTES[a] - WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-NOVEMBER, 1949

WASTE	VOLUME	TOTAL SOLIDS			VOLATILE SOLIDS		
		Total	Suspended	Filtrable	Total	Suspended	Filtrable
	gal/ton of beets	lb/ton of beets	lb/ton of beets	lb/ton of beets	lb/ton of beets	lb/ton of beets	lb/ton of beets
Flume Water	1760	77.4	63.5	14.5	11.7	5.5	6.2
Diffusion Battery	1420	23.6	7.4	16.2,	10.1	4.5	5.6
Filter Cake	46	44.9	43.5	1.4	7.9	7.4	0.5
Pulp Silo Drainage	270	10.8	0.4	10.4	7.9	0.3	7.6
Total	3496	156.7	114.8	42.5	37.6	17.7	19.9
Combined Factory, Uncorrected[b]	4060	128.0	77.5	46.3	33.9	12.5	21.4

(a) Weights are those computed using average data for volumes and solid determinations.

(b) Includes 320 gallons per ton irrigation water by-passing factory; excludes all (46 gallons per ton) Filter press wastes and 50 gallons per ton diffusion battery waste.

these wastes would soon fill with silt. The volatile suspended solids for all the wastes amounted to 17.7 pounds per ton of beets, and was reasonably equally divided between the flume water, diffusion battery and filter press wastes.

LAGOON STUDIES

During this survey limited studies were made of the treatment of the combined factory waste in lagoons. These studies may be divided into four separate phases:

(1) Treatment provided by the main lagoon through which the combined factory waste normally flowed.

(2) Comparison of the treatment obtained by lagooning unscreened and coarse screened combined factory waste.

(3) Comparison of the treatment resulting on lagooning unscreened and fine screened combined factory waste.

(4) Comparison of the treatment provided by lagooning medium screened combined factory waste (a) treated with ammonium nitrate, (b) treated with ammonium phosphate, and (c) with no chemicals added.

38. Main Lagoon Studies

The main lagoon, through which the combined factory waste[(a)] normally flowed, was a large irregular pool varying from a few inches to several feet in depth. No attempt was made to determine its capacity; however, this lagoon probably provided 3 to 5 days detention.

The treatment effected in this lagoon is indicated by comparing the data for the combined factory waste with that for the lagoon effluent. Such a comparison is shown in Table 5. The results of the analytical determinations for each sample collected are given in Appendix A.

The suspended solids removal in this lagoon was excellent. The total suspended solids in the influent and effluent averaged 2,292 and 33 ppm, respectively. This showed a reduction of 98.6% in suspended solids. The reduction for volatile suspended solids was 95.2%. The BOD of the influent and effluent samples averaged 652 and 575 ppm, respectively. The indicated reduction in BOD loading was 11.6%.

In general, lagoons of this type will produce an effluent relatively free from sludge producing solids, but having a BOD concentration only slightly below that of the untreated waste.

(a) As previously noted, the combined factory waste did not include filter cake waste and that diffusion battery waste diverted to flush the ash pit.

TABLE 5 - AVERAGE CHARACTERISTICS OF MAIN LAGOON INFLUENT AND EFFLUENT, AND REDUCTION EFFECTED WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-DECEMBER, 1949

DETERMINATION	AVERAGE ANALYTICAL DATA		REDUCTION
	Combined Factory Waste	Lagoon Effluent	Per Cent
Waste Flow (gpd)	6,571,000	3,916,000(a)	-
Temperature (°C.)	25	13	-
pH	6.[illegible]	6.2	-
Alkalinity, Total (ppm)	227	328	-
BOD, 5-day, 20°C. (ppm)	652	[illegible]75	21.6
Total Solids, Total (ppm)	3659	1777	50.2
Suspended (ppm)	2292	3[illegible]	98.6
Filt. (ppm)	1367	1734	-26.8
Volatile Solids, Total (ppm)	994	5[illegible]0	45.9
Suspended (ppm)	336	1[illegible]	95.2
Filt. (ppm)	628	[illegible]24	16.5
Ammonia Nitrogen (ppm)	3.4	1.[illegible]	-
Organic Nitrogen (ppm)	17.7	6.8	61.6

(a) Part of the combined factory waste flow was diverted to the irrigation ditch used to supply waste for the experimental lagoon studies; moreover, some waste seeped through the dikes forming the lagoon.

39. Experimental Lagoons

The temporary facilities installed for these studies consisted of a pumping station, a mechanical vibrating screen, flow measurement devices, and four lagoons. Each lagoon, which was approximately 100 by 210 feet in plan with a depth averaging about 4 feet, provided approximately 630,000 gallons storage.

The factory waste was diverted to an irrigation ditch from which it was pumped. During the studies of the effect of screening, a portion of this waste was discharged directly to Lagoon No.1, while the balance was screened. The discharge to Lagoon No.1 passed through a stilling box and a 90° V-notch weir. The screened waste flowed through a 6-inch Parshall flume to a header from which it could be diverted to either lagoons 2, 3, or 4. The effluent from each lagoon discharged through a 90° V-notch triangular weir.

Prior to studying the effect of adding nitrate and phosphate to the influents to these lagoons, the following alterations were made: All wastes which were pumped, flowed through the screen, the effluent from which discharged to a common header. The influent to each lagoon was drawn from this header through a valved pipe and flowed into a stilling box and through a sharp-edged, V-notch weir, specially installed for this study.

40. Results of Lagooning Coarse Screened Wastes

During the period October 13 through October 19 unscreened waste was discharged into Lagoon No.1 and coarse screened (5/32" x 10/16" clear openings) waste was discharged into Lagoon No.4. Since this screen was found to be ineffective in removing such suspended solids as the spent cassettes, the coarse screen study was discontinued.

41. Results of Lagooning Fine Screened Wastes

A fine screen (1/32" x 9/[illegible]" c c) was installed and commencing October 22 the screened waste was discharged into Lagoon No.2. Lagoon No.1 again received unscreened waste.

It had been planned to discharge 1/2 cfs (323,000 gpd) to each lagoon. However, the setting of the staff gage indicating the head on the V-notch weir was found to be inaccurate and the average measured flow to Lagoon No.1 was 372,000 gpd for the period October 22 to 29; thereafter, it averaged 323,000 gpd. The flow into Lagoon No.2 was quite constant and averaged 320,000 gpd.

Table 6 gives the average analytical data obtained for each lagoon. The analytical results for each sample may be found in Appendix C. Inspection of the average data shows that the influents to these lagoons have similar characteristics; the greatest difference is in the volatile suspended solids - material such as waste cassettes which should be removed on the screen.

TABLE 6 - COMPARISON OF TREATMENT EFFECTED BY LAGOONING UNSCREENED AND SCREENED STRAIGHT HOUSE BEET SUGAR FACTORY WASTE
WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY
OCTOBER-DECEMBER, 1949

Determination		AVERAGE DATA FOR Lagoon No. 1 - Unscreened Waste Influent	Effluent	% Red.	Lagoon No. 2 - Screened Waste (1/32" x 9/32" c o) Influent	Effluent	% Red.
Flow	(gpd)	346,900	283,300	-	319,600	154,300	-
Temperature	(°C.)	25	20	-	25	20	-
pH		6.4	5.5	-	6.5	5.6	-
Alkalinity, Total	(ppm)	252	230	8.6	246	224	8.9
BOD, 5-day, 20°C.	(ppm)	658	588	10.6	646	548	15.1
Total Solids, Total	(ppm)	4,052	1,735	57.2	3,943	1,752	55.5
Suspended	(ppm)	2,670	105	96.1	2,681	82	96.9
Filtrable	(ppm)	1,382	1,630	-18.2	1,262	1,670	-32.3
Volatile Solids, Total	(ppm)	1,024	492	52.0	975	508	47.9
Suspended	(ppm)	412	35	91.5	337	28	91.7
Filtrable	(ppm)	612	457	25.3	638	480	24.8
Ammonia Nitrogen	(ppm)	3.3	2.1	36.4	3.4	0.9	73.6
Organic Nitrogen	(ppm)	19.1	7.7	59.7	18.1	7.9	56.4

Due to seepage through the dikes raised to form these lagoons, and probably through the exposed gravel strata in their bottoms, the volumes of the influent and effluent for each of these lagoons did not check. Since such lagoons would normally be, or soon become, relatively water tight, it appears desirable in this report to base the treatment obtained on the relative concentrations of the lagoon influent and effluent.

The BOD of the influent to each lagoon averaged approximately 650 ppm. The average BOD reduction secured in passing the unscreened waste through Lagoon No.1 was 10.4%, and that secured in passing screened waste through Lagoon No.2 was 15.1%. Both lagoons gave marked reductions in total suspended and volatile suspended solids, the concentrations of which were reduced by approximately 96 and 92 per cent, respectively.

In conclusion both lagoons were effective in removing suspended solids, and Lagoon No.2, which received screened waste, gave a slight, but hardly significant, greater BOD reduction.

The fine vibrating screen, which was approximately 4 feet by 6 feet in area, passed 1/2 cfs of waste with practically no maintenance, but required cleaning at approximately hourly intervals when the flow was increased to around 1 1/2 to 2 cfs. The principal difficulty was due to the fine hair-like roots from the beets clogging the screen openings.

42. Results on Lagooning Nitrate and Phosphate Treated Wastes

In view of the apparent limitation in the reduction of the BOD concentration obtained by lagooning screened waste, it was decided to attempt to accelerate the biological treatment process by the addition of chemicals. Drawing on the experience with cannery wastes (9) and various experimental investigations with phosphorus deficient wastes, also considering their availability, the chemicals selected were ammonium nitrate and ammonium phosphate.

For this study three lagoons (numbers 1, 2, and 3) were operated in parallel. All waste was passed through a screen having 1/16" x 5/16" clear openings. The influent to each lagoon was measured by a sharp-edged, 90°, V-notch weir specially installed for this study. Ammonium nitrate (33 1/3% N) was added to the influent to Lagoon No.1; ammonium

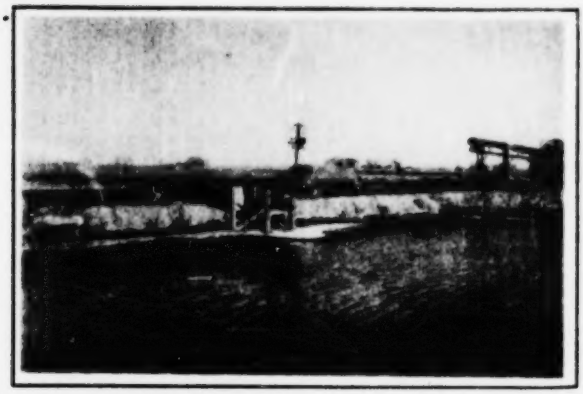


Fig. 8. Experimental Lagoon No.2 showing the measuring weir, common header from which wastes discharged to each lagoon and at the extreme right the mechanical vibrating screen.

was added to the influent to Lagoon No.1; ammonium phosphate (20% P_2O_5), to Lagoon No.2; and no chemical was added to Lagoon No. 3. These chemicals were added at half hour intervals by filling a measuring can - cut to hold the desired weight of chemical when filled level to the top - with the chemical and dumping it into the influent weir box. Lagoon No.1 received 83.8 pounds of ammonium nitrate per 100,000 gallons of waste. This was equivalent to 60 ppm nitrate oxygen, or that amount estimated to be 10% of the 5-day BOD. (Actually the BOD of the influent averaged 757 ppm, so the oxygen added in the form of nitrates amounted to only 8% of the 5-day BOD).

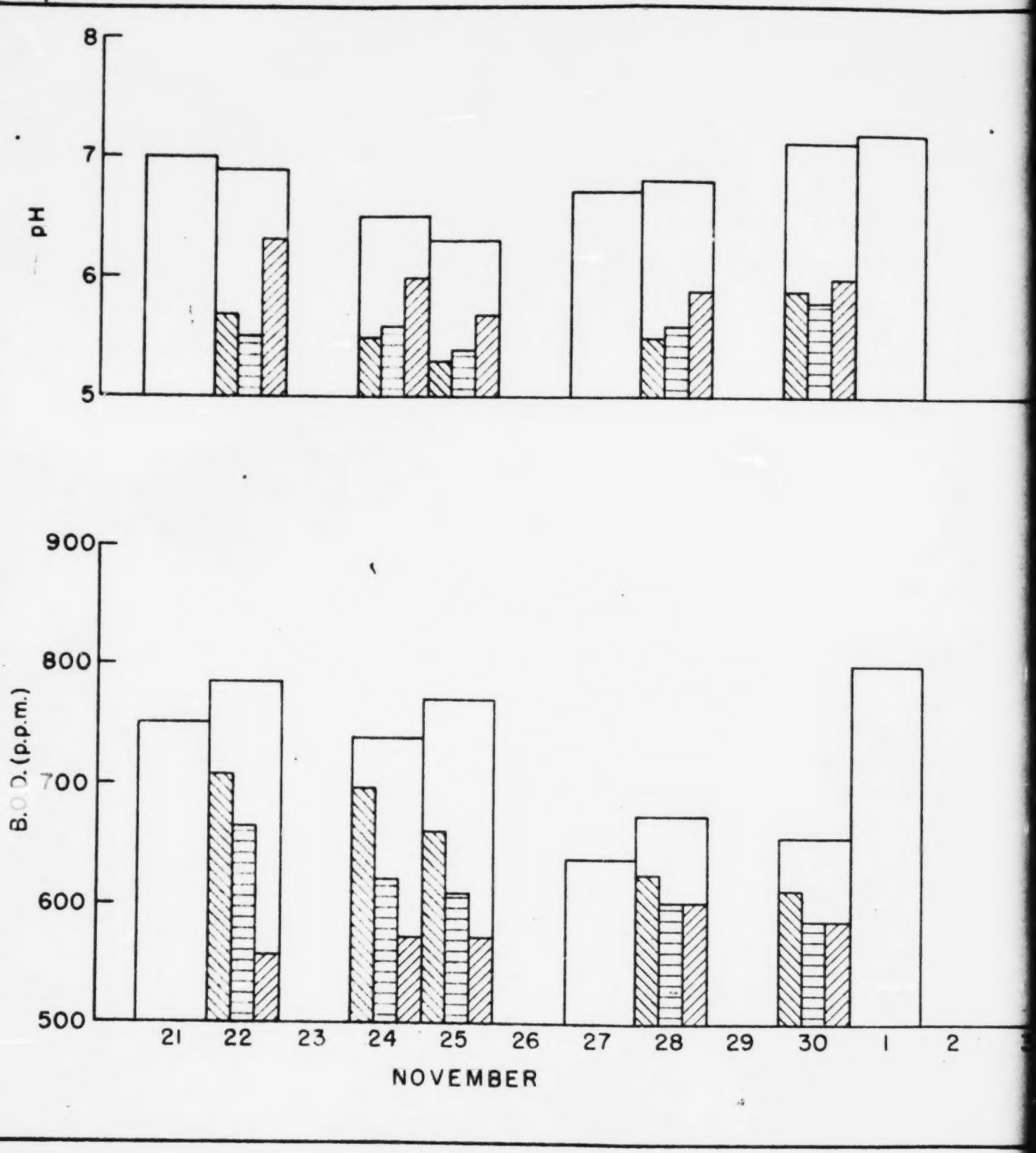
Lagoon No.2 received 95 pounds of super ammonium phosphate per 100,000 gallons. This was equivalent to 10 ppm phosphorus, which was estimated to be in excess of the probable nutritional requirements for any flora or faunae which might be in the lagoon.

In order to fillthe lagoons theflow into each was maintained at 0.4 cfs for the first 46 hours, thereafter the rate was held at 0.2 cfs except for two periods (December 26 and 29) during which the pump was shut down for repair.

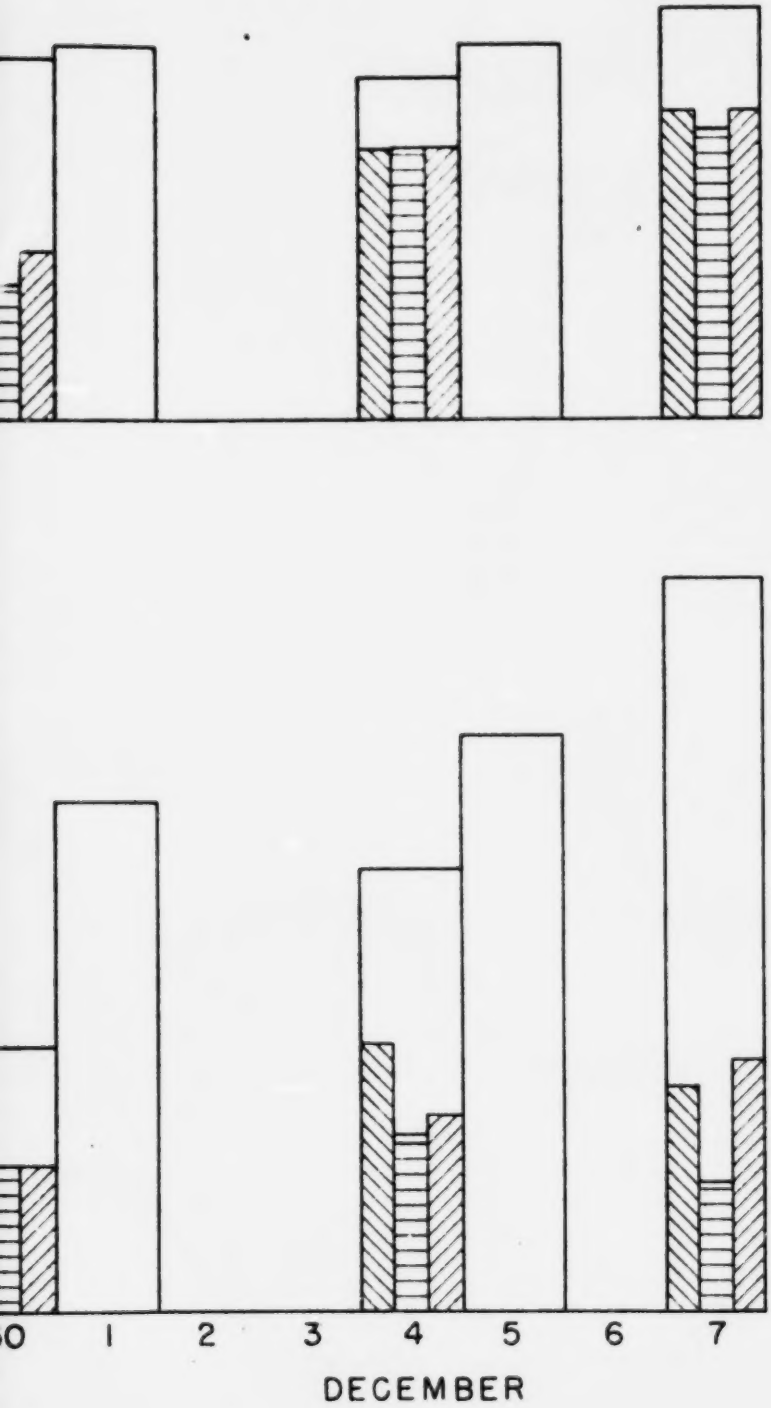
Sampling data and analytical results for all samples collected are given in Appendix D. Figure 9 shows the change in the relative order of the pH and BOD determinations during the course of the study. It is believed that these data present a picture of changing conditions, which might be due to the presence of sludge deposits in lagoons 1 and 2, and the gradual development of flora and faunae active in the decomposition of the waste.

Except for the period during which the lagoons were filled and the two days (December 26 and 29) on which the pump was stopped for repair, the flow

A


8
7
6
5
pH
900
800
700
600
500
B.O.D. (p.p.m.)
21
22
23
24
25
26
27
28
29
30
1
2
NOVEMBER

B



LEGEND

Influent, all lagoons

Effluent, lagoon No.1 – Wit
of 83.8 lb. ammonium
gallons of waste.

Effluent, lagoon No.2 – Wit
of 95 lb. super ammon
100,000 gallons of wa

Effluent, lagoon No.3 – C
added to inflowing wa

FIGURE
COMPARISON OF pH
INFLUENTS & EFFLUENTS
WINDSOR BEET SUG
GREAT WESTERN SU
WINDSOR, COL
FEDERAL SECURIT
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ENVIRONMENTAL HEAL
CINCINNATI, OHIO NOV

LEGEND

Influent, all lagoons

Effluent, lagoon No.1 – With addition to influent of 83.8 lb. ammonium nitrate per 100,000 gallons of waste.

Effluent, lagoon No.2 – With addition to influent of 95 lb. super ammonium phosphate per 100,000 gallons of waste.

Effluent, lagoon No.3 – Control, no chemicals added to inflowing waste.

FIGURE 9

COMPARISON OF pH & B.O.D. OF INFLUENTS & EFFLUENTS FROM LAGOONS

WINDSOR BEET SUGAR FACTORY
GREAT WESTERN SUGAR COMPANY
WINDSOR, COLORADO
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO NOVEMBER – DECEMBER, 1949

to each lagoon was held constant at 129,000 gpd. Due to seepage through the bottom and the earth dikes forming the lagoons the effluent from each lagoon was somewhat less than 129,000 gpd. Based on the influent flow the theoretical detention period was 5 days.

The temperature of the influent to each lagoon averaged 21°C. That of each effluent gradually dropped from 14 or 15°C. on November 22 to 10°C. on December 7.

The pH of the influents varied from 6.3 to 7.4 and averaged 6.9. That of the effluents from lagoons 1, 2 and 3 averaged 5.9, 5.9 and 6.2, respectively. Of particular interest is the change in the relation of the pH of the effluents from these three lagoons. Fig. 9 shows that during the early period of the study the pH of the effluents from lagoons 1 and 2 were less than that of the effluent of the control lagoon. Gradually this condition changed and the pH values of all three effluents were of the same magnitude.

The BOD of the common influent varied from 638 to 928 ppm and averaged 757 ppm. That for the effluent for lagoons 1, 2 and 3 averaged 659, 608 and 592 ppm, respectively. Reference to Fig. 9 shows the changing magnitudes in the relative strengths of the effluents. The effluent from lagoons numbers 1 and 2, which were relatively strong in the early stage, gradually decreased in strength until the BOD of the effluent from the control lagoon was the highest. The soluble phosphorus content of the influent waste averaged 0.3 ppm. In several instances the effluents from lagoons 1 and 3 contained less than 0.05 ppm phosphorus. The average soluble phosphorus concentration in Lagoon No.2 was 7.9 ppm, which indicates phosphorus was present in excess of that utilized by the biological life.

The most significant results of the nitrogen determinations are the increasing amounts of nitrite nitrogen found in the effluent from Lagoon No.1. This indicates the gradual development of a flora and fauna active in reducing the nitrates.

There is evidence that the accumulations of sludge in lagoons numbers 1 and 2 affected the results in the early days of the experiment. Gradually, however, the effluents from these lagoons improved when compared to that from the control lagoon. This is believed due to the development of a flora and fauna capable of utilizing the nitrate or phosphorus. It may be concluded that the duration of these studies was too short to determine what, if any, benefits might result from the addition of either of these chemicals to lagooned beet sugar factory wastes.

ACKNOWLEDGMENT

It is desired to express appreciation to Mr. A. A. Clark, Vice President and General Superintendent of the Great Western Sugar Company, whose interest resulted in this cooperative survey; to Mr. A. R. Nees, and other personnel of the Denver Office; and to Mr. Watson, Manager; Mr. M. Schmode, Plant Superintendent; Mr. J. R. Goodner, Master Mechanic; Mr. C. H. McCurry, Chief Chemist; and other personnel of the Windsor Factory for the cooperation and assistance extended during the conduct of this survey.

Graham Walton
Sanitary Engineer.

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APPENDIX A

SAMPLING DATA AND ANALYTICAL RESULTS FOR FACTORY WASTES

APPENDIX A - SAMPLING DATA AND ANALYTICAL RESULTS FOR FACTORY WASTES - WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-NOVEMBER, 1949

Sample	Date of Sampling 1949	Method of Collection and Compositing	Beets Processed 8 AM-4 PM Shift Tons	Flow 8-Hr. Av. gpd	Temperature Min °C	Temperature Av °C	Temperature Max °C	pH	Total Alkalinity as $CaCO_3$ ppm	BOD 5-Day 20°C ppm	Total Solids Total ppm	Total Solids Suspended ppm	Total Solids Filtrable ppm	Volatile Solids Total ppm	Volatile Solids Suspended ppm	Volatile Solids Filtrable ppm	Nitrogen NH_3 ppm	Nitrogen Organic ppm
Flume Water Waste-Up-stream from Weir	Nov. 3	8-Hr. Composite Consisting of 3 Equal Portions Collected Hourly	681	Estimated to Average 2,800,000 gpd	23	26	29	7.5	210	241	4600	2740	1940	780	280	500	-	-
	Nov. 4		664		23	26	31	7.7	-	189	-	-	-	-	-	-	4.7	-
	Nov. 8		544		23	28	32	7.5	260	200	4110	2590	1520	640	230	410	1.7	13.7
	Nov. 9		632		26	28	32	7.5	203	199	5940	5450	490	920	470	450	4.5	15.0
	Nov.11		762		24	27	28	7.7	-	197	-	-	-	-	-	-	-	-
	Nov.14		665		20	26	29	7.8	-	205	-	-	-	-	-	-	4.9	17.7
	Nov.15		636		25	28	33	7.8	263	197	6420	6420	0	900	550	350	-	-
	Nov.16		536		25	28	29	7.8	-	191	-	-	-	-	-	-	4.1	17.3
	Nov.17		626		13	26	31	6.0	237	191	5180	4190	990	790	390	400	-	-
	Nov.18		646		21	26	31	6.7	-	200	-	-	-	-	-	-	-	-
	No. of Determinations		10		10	10	10	10	5	10	6	6	6	6	5	6	5	4
	Average		544	2,800,000	-	27	-	7.6	236	194	5266	4302	988	804	382	422	4.0	15.9
	Maximum		665		-	28	33	8.0	263	241	6420	6420	1940	920	550	610	4.9	17.7
	Minimum		626		13	26	-	6.7	203	191	4110	2590	0	640	230	360	1.7	13.7

APPENDIX A - SAMPLING DATA AND ANALYTICAL RESULTS FOR FACTORY SAMPLE 2 - MINNEAPOLIS FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-NOVEMBER, 1949

Sample	Date of Sampling 1949	Method of Collection and Composition	Beets Processed 8 AM-4 PM Shift Tons	Flow 8-Hr. av. gpd	Temperature Min °C	Temperature Av °C	Temperature Max °C	pH	Total Alkalinity $CaCO_3$ ppm	BOD 5-Day 20° C ppm	Total Solids Total ppm	Total Solids Suspended ppm	Total Solids Filtrable ppm	Volatile Solids Total ppm	Volatile Solids Suspended ppm	Volatile Solids Filtrable ppm	Nitrogen NH_3 ppm	Nitrogen Organic ppm
Diffusion Battery Waste - Main Sewer Effluent	Oct. 11	8-Hr. Composite Consisting of 8 Equal Portions Collected Hourly	641	-	34	39	42	7.6	163	666	-	-	-	-	-	-	-	-
	Oct. 12		[illegible]	-	32	37	41	7.6	143	669	-	-	-	-	-	-	-	-
	Oct. 13		[illegible]	-	34	37	42	7.6	141	616	-	-	-	-	-	-	-	-
	Oct. 14		[illegible]	-	34	38	41	7.4	144	669	-	-	-	-	-	-	-	-
	Oct. 31		641	-	31	34	37	7.7	176	397	2070	740	1330	910	430	48	-	-
	Nov. 1		[illegible]	[illegible]	32	33	34	7.8	-	349	-	-	-	-	-	-	-	-
	Nov. 2		[illegible]	[illegible]	[illegible]	34	37	7.7	166	612	2100	660	1500	930	380	550	3.4	18.6
	Nov. 4		[illegible]	[illegible]	31	33	36	7.9	-	472	-	-	-	-	-	-	-	-
	Nov. 14		[illegible]	-	[illegible]	34	38	[illegible]	-	416	-	-	-	-	-	-	[illegible]	[illegible]
	Nov. 15		[illegible]	[illegible]	[illegible]	31	34	[illegible]	162	[illegible]	1860	740	1140	790	410	380	6.1	17.9
	Nov. 16		[illegible]	[illegible]	28	32	35	7.9	-	420	-	-	-	-	-	-	-	-
	Nov. 17		[illegible]	[illegible]	31	34	36	8.0	161	473	1960	560	1400	860	380	480	6.2	17.2
	Nov. 18		[illegible]	[illegible]	28	34	38	[illegible]	-	[illegible]	-	-	-	-	-	-	-	-
	No. of Determinations		13	7	-	13	-	13	9	13	4	4	4	4	4	4	4	4
	Average		641	[illegible]	-	34	-	7.9	149	[illegible]	[illegible]	666	1342	872	420	442	[illegible]	[illegible]
	Maximum		665	[illegible]	-	39	42	8.0	181	666	2100	740	1500	930	430	550	6.6	18.6
	Minimum		624	[illegible]	-	31	-	[illegible]	143	349	1860	560	1140	860	380	380	3.4	[illegible]

APPENDIX A - SAMPLING DATA AND ANALYTICAL RESULTS FOR FACTORY WASTES - WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-NOVEMBER, 1949

Sample	Date of Sampling 1949	Method of Collection and Compositing	Beets Processed 8 AM-4 PM Shift Tons	Flow 8-Hr. Av. gpd	Temperature Min. °C	Temperature Av. °C	Temperature Max. °C	pH	Total Alkalinity Ca CO_3 ppm	BOD 5-Day 20°C ppm	Total Solids Total ppm	Total Solids Suspended ppm	Total Solids Filtrable ppm	Volatile Solids Total ppm	Volatile Solids Suspended ppm	Volatile Solids Filtrable ppm	Nitrogen NH_3 ppm	Nitrogen Organic ppm
Diffusion Battery Waste - Relief Screen Effluent	Oct. 11	8-Hr. Composite Consisting of 8 Equal Portions Collected Hourly	641	663,000	[illegible]	38	45	7.7	154	595	-	-	-	-	-	-	-	-
	Oct. 12		624	2,000	28	38	42	7.8	143	675	-	-	-	-	-	-	-	-
	Oct. 13		632	467,000	29	34	44	7.8	158	560	-	-	-	-	-	-	-	-
	Oct. 14		647	[illegible]	31	37	44	7.7	149	685	-	-	-	-	-	-	-	-
	Oct. 31		641	641,000	25	37	46	8.7	185	555	1860	550	1310	820	320	500	-	-
	Nov. 1		632	[illegible]	28	31	36	7.9	-	420	-	-	-	-	-	-	5.5	14.6
	Nov. 2		667	[illegible]	26	31	43	7.9	170	467	2100	620	1480	830	370	460	-	-
	Nov. 3		661	[illegible]	28	33	40	7.7	160	442	1940	420	1520	800	260	540	-	-
	Nov 4		674	[illegible]	24	36	42	7.9	-	406	-	-	-	-	-	-	7.6	17.9
	Nov. 14		666	[illegible]	20	32	43	8.0	-	474	-	-	-	-	-	-	6.0	17.0
	Nov. 15		636	700,000	18	27	36	8.0	171	380	1880	390	1490	670	270	400	-	-
	Nov. 16		636	600,000	27	31	42	7.7	-	531	-	-	-	-	-	-	5.5	16.4
	Nov. 17		626	[illegible]	27	34	40	7.8	162	582	1920	540	1380	[illegible]	370	[illegible]	-	-
	Nov. 18		646	[illegible]	22	28	34	7.9	-	481	-	-	-	-	-	-	-	-
	No. of Determinations		14	14		14		14	9	14	5	5	5	5	5	5	4	4
	Average		[illegible]	[illegible]		[illegible]		7.9	162	533	1940	514	1436	798	318	480	6.2	17.0
	Maximum		667	[illegible]		38	46	8.7	185	685	2100	620	1520	830	370	540	7.6	17.9
	Minimum		624	[illegible]	18	27		7.7	143	380	1860	390	1310	670	260	400	5.5	16.4

APPENDIX A - SAMPLING DATA AND ANALYTICAL RESULTS FOR FACTORY WASTES - DIVISION FACTORY, BRATTLEBORO, VERMONT, BRATTLEBORO STEAM LAUNDRY COMPANY, OCTOBER-NOVEMBER, 1949

Sample	Date of Sampling (1949)	Method of Collection and Compositing	Sheets Processed 8 AM-4 PM Shifts	Flow 24-Hr. Av. gpd	Temperature			pH	Alkalinity ($CaCO_3$)		BOD 5-Day 20° C mg/l	Total Solids			Volatile Solids			Nitrogen	
					Min °C	Av °C	Max °C		Phth. mg./l	Total mg./l		Total mg./l	Suspended mg./l	Filtrable mg./l	Total mg./l	Suspended mg./l	Filtrable mg./l	NH_3 mg./l	Organic mg./l
Filter Cake wastes from Inlet to Lagoon	Oct. 11	24-Hr. Composite of 8 Portions Collected Hourly and Composited Volumetrically According to Flow	541	95,600	18	22	29	-	9800	18000	-	-	-	-	-	-	-	-	-
	Oct. 12		534	82,500	17	23	29	-	10600	19000	-	-	-	-	-	-	-	-	-
	Oct. 13		532	87,000	23	25	27	-	12300	24000	12000	-	-	-	-	-	-	-	-
	Oct. 14		547	78,600	17	24	30	-	9400	16800	11500	-	-	-	-	-	-	-	-
	Oct. 31		541	59,500	21	24	27	-	9100	16600	14500	137,600	124,900	4000	21,200	19,800	2,400	-	-
	Nov. 1		532	73,700	23	25	28	-	-	-	13500	-	-	-	-	-	-	6.1	7.6
	Nov. 2		547	67,900	19	23	26	-	6600	6900	11200	124,900	12,400	4500	23,500	22,000	1,500	-	-
	Nov. 3		561	49,800	23	25	30	-	-	-	-	-	-	-	-	-	-	-	-
	Nov. 4		564	103,300	21	25	27	-	-	-	10700	-	-	-	-	-	-	7.4	7.1
	Nov. 14		565	67,200	16	18	20	11.8	-	-	7000	-	-	-	-	-	-	1.9	1.4
	Nov. 15		536	89,500	16	19	22	11.9	4200	5400	8600	96,000	91,300	4700	14,500	14,500	0	-	-
	Nov. 16		538	81,700	17	23	26	11.8	-	-	9800	-	-	-	-	-	-	-	-
	Nov. 17		526	76,500	13	21	30	11.8	4000	5400	10000	106,000	101,700	4300	25,000	25,000	0	1.2	0.7
	Nov. 18		540	107,200	16	21	21	11.7	-	-	8600	-	-	-	-	-	-	-	-
	No. of Determinations		14	14	-	14	-	5	9	9	11	4	4	4	4	4	4	4	4
	Average		542	84,700	-	23	-	11.9	7100	12700	1.98	117,500	112,700	4700	21,300	19,900	1,450	4.7	4.7
	Maximum		565	107,200	-	25	30	11.9	12300	24000	14500	137,600	124,900	4700	25,000	25,000	2,400	7.4	7.6
	Minimum		526	67,900	13	18	-	11.7	4000	5400	7000	96,000	91,300	4300	14,500	14,500	0	1.9	0.4

APPENDIX A - SAMPLING DATA AND ANALYTICAL RESULTS FOR FACTORY WASTES - MINOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-NOVEMBER, 1949

Sample	Date of Sampling 1949	Method of Collection and Compositing	Hours Processed 8 AM-4 PM Shift Tons	Flow 8-Hr. Av. gpd	Temperature Min °C	Temperature Av °C	Temperature Max °C	pH	Acidity as $CaCO_3$ ppm	BOD 5-Day 20°C ppm	Total Solids Total ppm	Total Solids Suspended ppm	Total Solids Filtrable ppm	Volatile Solids Total ppm	Volatile Solids Suspended ppm	Volatile Solids Filtrable ppm	Nitrogen NH_3 ppm	Nitrogen Organic ppm
Pulp	Oct. 11	8-Hr. Com-	541	488,000	30	33	34	4.1	-	3440	-	-	-	-	-	-	-	-
Silo	Oct. 12	posite	524	451,000	31	33	34	4.2	-	3440	-	-	-	-	-	-	-	-
Drainage	Oct. 13	Consisting	532	465,000	32	33	34	4.1	-	4080	-	-	-	-	-	-	-	-
	Oct. 14	of 8 Por-	547	414,000	32	34	36	4.1	-	4080	-	-	-	-	-	-	-	-
	Oct. 31	tions Col-	541	454,000	31	31	32	4.1	-	42	4440	90	4350	3180	90	3090	-	-
	Nov. 1	lected	532	491,000	31	32	33	4.1	-	4200	-	-	-	-	-	-	2.6	69.2
	Nov. 2	Hourly	557	447,000	31	31	32	4.0	-	4250	4660	110	4550	340	90	4510	-	-
	Nov. 3	and Com-	562	414,000	31	32	32	4.0	-	4200	4470	140	4330	3330	130	3200	-	-
	Nov. 4	posited	554	390,000	31	31	32	4.1	-	4200	-	-	-	-	-	-	2.6	69.0
	Nov. 15	Volu-	530	-	28	31	31	3.9	-	6550	4430	190	4240	3140	40	3100	-	-
	Nov. 16	metrically	530	-	29	30	31	3.9	-	7060	-	-	-	-	-	-	3.4	84.7
	Nov. 17	According	524	-	29	30	31	3.8	3000	7200	4260	120	4140	3240	140	3100	-	-
	Nov. 18	to Flow	546	-	29	30	31	4.0	-	6340	-	-	-	-	-	-	-	-
	No. of Determinations		13	9	-	13	-	13	1	13	5	5	5	5	5	5	3	3
	Average		540	439,000	-	32	-	4.0	3000	4611	4291	148	4262	3211	140	3138	2.4	74.4
	Maximum		557	488,000	-	34	36	4.2	-	7200	4660	190	4550	3340	240	3200	-	-
	Minimum		524	390,000	28	30	-	3.8	-	3440	4260	90	4140	3140	90	3090	-	-

APPENDIX A - SAMPLING DATA AND ANALYTICAL RESULTS FOR FACTORY WASTES - WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-NOVEMBER, 1949

Sample	Date of Sampling 1949	Method of Collection and Compositing	Beets Processed 8 AM-4PM Shift Tons	Flow 8-Hr. Av. gpd	Temperature Min °C	Temperature Av °C	Temperature Max °C	pH	Total Alkalinity $CaCO_3$ ppm	BOD 5-Day 20°C ppm	Total Solids Total ppm	Total Solids Suspended ppm	Total Solids Filtrable ppm	Volatile Solids Total ppm	Volatile Solids Suspended ppm	Volatile Solids Filtrable ppm	Nitrogen NH_3 ppm	Nitrogen Organic ppm
Combined Factory Wastes - (Filter Cake waste & Ash Pit Drainage are not Included)	Oct. 11	8-Hour Composite Consisting of 8 Equal Portions Collected Hourly	541	7,080,000	24	26	27	6.5	189	620	-	-	-	-	-	-	-	-
	Oct. 12		524	7,070,000	23	25	27	6.8	184	473	-	-	-	-	-	-	-	-
	Oct. 13		532	6,830,000	23	25	28	6.6	195	664	-	-	-	-	-	-	-	-
	Oct. 14		547	6,630,000	23	26	28	6.6	190	624	-	-	-	-	-	-	-	-
	Oct. 17		537	6,770,000	23	26	29	6.7	202	637	3150	1390	1760	870	280	590	-	-
	Oct. 18		508	6,600,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Oct. 19		545	6,460,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Oct. 24		505	6,200,000	21	26	28	6.9	321	1026	4090	2620	1470	1290	450	840	-	-
	Oct. 25		527	6,270,000	22	26	27	6.6	-	555	-	-	-	-	-	-	3.6	17.7
	Oct. 26		546	6,320,000	24	26	28	6.5	216	559	3670	2370	1300	940	450	490	-	-
	Oct. 27		546	6,320,000	26	27	29	6.3	-	752	-	-	-	-	-	-	3.1	17.2
	Oct. 28		539	6,360,000	21	26	28	6.6	228	627	3370	1990	1380	920	270	650	-	-
	Oct. 31		541	6,560,000	22	24	27	6.6	260	676	3770	2610	1160	980	600	470	-	-
	Nov. 1		532	6,630,000	23	25	27	6.2	-	668	-	-	-	-	-	-	4.9	18.8
	Nov. 2		557	6,700,000	24	26	28	5.9	218	850	3790	3330	420	1120	440	680	-	-
	Nov. 3		551	6,800,000	23	25	27	6.4	212	619	3560	1980	1580	890	260	630	-	-
	Nov. 4		554	6,660,000	23	25	27	6.4	-	612	-	-	-	-	-	-	4.0	14.1
	Nov. 14		566	6,360,000	21	24	26	6.8	-	617	-	-	-	-	-	-	3.8	19.0
	Nov. 15		536	6,390,000	21	24	26	6.6	231	682	3610	2070	1440	950	290	660	-	-
	Nov. 16		536	6,350,000	19	24	25	7.1	-	678	-	-	-	-	-	-	3.9	18.7
	Nov. 17		526	6,380,000	19	24	25	7.3	302	717	4060	2670	1690	1180	350	730	-	-
	Nov. 18		546	6,390,000	22	24	27	6.0	-	686	-	-	-	-	-	-	-	-
	No. of Determinations		20	20	-	20	-	20	13	20	9	9	9	9	9	9	6	6
	Average		538	6,671,000	-	25	-	6.5	227	652	3669	2292	1367	994	366	628	3.4	17.7
	Maximum		566	7,080,000	-	27	29	7.3	302	1026	4090	3330	1760	1290	600	840	5.0	19.0
	Minimum		505	6,200,000	19	24	-	6.0	189	473	3150	1390	420	870	260	470	1.9	14.1

APPENDIX A - SAMPLING DATA AND ANALYTICAL RESULTS FOR FACTORY WASTES - WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-NOVEMBER, 1949

Sample	Date of Sampling 1949	Method of Collection and Compositing	Beets Processed 8 AM-4 PM Shift Tons	Flow 8-Hr. Av. gpd	Temperature Min °C	Temperature Av °C	Temperature Max °C	pH	Total Alkalinity $CaCO_3$ ppm	BOD 5-Day 20°C ppm	Total Solids Total ppm	Total Solids Suspended ppm	Total Solids Filtrable ppm	Volatile Solids Total ppm	Volatile Solids Suspended ppm	Volatile Solids Filtrable ppm	Nitrogen NH_3 ppm	Nitrogen Organic ppm
Main Lagoon Effluent - Upstream from Overflow Weir	Oct. 24	8-Hour Composite Consisting of 4 Equal Portions Collected Every 2 Hours		3,350,000	13	15	16	5.7	270	579	1760	40	1720	554	14	540	-	-
	Oct. 25			4,080,000	15	17	18	6.9	-	501	-	-	-	-	-	-	1.0	7.6
	Oct. 26			3,800,000	15	17	19	6.9	260	489	1690	30	1660	515	10	505	-	-
	Oct. 27			3,640,000	16	17	18	6.9	-	519	-	-	-	-	-	-	1.2	6.
	Oct. 28			3,080,000	13	16	18	6.9	351	542	1890	3	1760	545	19	526	-	-
	Nov. 8			4,370,000	11	12	14	6.5	-	612	-	-	-	-	-	-	1.6	7.9
	Nov. 21			3,920,000	8	9	11	6.5	-	694	-	-	-	-	-	-	1.4	-
	Nov. 24			4,190,000	1	11	12	6.7	432	575	-	-	-	-	-	-	1.2	-
	Dec. 7			4,340,000	6	7	8	7.0	-	463	-	-	-	-	-	-	-	-
	No. of Determinations			9	-	9	-	9	4	9	3	3	3	3	3	3	3	3
	Average			3,910,000	-	13	-	6.8	328	575	1777	11	1743	438	14	64	1.3	6.9
	Maximum			4,340,000	-	17	19	7.0	432	694	-	-	-	-	-	-	1.6	-
	Minimum			3,080,000	6	7	-	6.7	260	489	-	-	-	-	-	-	1.0	-

APPENDIX B

B.O.D. DATA, INCLUDING POPULATION EQUIVALENTS, FOR STRAIGHT HOUSE BEET SUGAR FACTORY WASTES

APPENDIX B – B.O.D. DATA, INCLUDING POPULATION EQUIVALENTS, FOR STRAIGHT HOUSE BEET SUGAR FACTORY WASTES
WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-NOVEMBER, 1949

SAMPLE	Date 1949	BEETS PROCESSED 8 AM-4 PM Shift Tons	BEETS PROCESSED Per Day Tons	FLOW 8-Hr. Av. gpd	B. O. D. ppm	B. O. D. lb./day	B. O. D. lb./ton	POPULATION EQUIVALENT Persons/Ton/Day
Flume Water Waste	Nov. 3	551	1653	2,880,000	241	5,790	3.50	20.9
	Nov. 4	554	1662		189	4,540	2.73	16.3
	Nov. 8	544	1632		200	4,800	2.94	17.6
	Nov. 9	532	1596		199	4,780	3.00	18.0
	Nov.11	552	1656		187	4,490	2.71	16.2
	Nov.14	565	1695		205	4,920	2.90	17.4
	Nov.15	536	1608		187	4,490	2.79	16.7
	Nov.16	536	1608		181	4,350	2.71	16.2
	Nov.17	526	1578		151	3,620	2.30	13.8
	Nov.18	546	1638		200	4,800	2.93	17.6
	Average	544	1633	2,880,000	194	4,658	2.85	17.1
	Maximum	565	1695		241	5,790	3.50	20.9
	Minimum	526	1596		151	3,620	2.30	13.8

APPENDIX B - B.O.D. DATA, INCLUDING POPULATION EQUIVALENTS, FOR STRAIGHT HOUSE BEET SUGAR FACTORY WASTES
WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-NOVEMBER, 1949

SAMPLE	DATE 1949	BEETS PROCESSED: 8 AM-4 PM Shift Tons	BEETS PROCESSED: Per Day Tons	FLOW: 8-Hr. Av. gpd	B. O. D.: ppm	B. O. D.: lb./day	B. O. D.: lb./ton	POPULATION EQUIVALENT: Persons/Ton/Day
Diffusion Battery	Nov. 1	532	1596	1,760,000	349	5,130	3.21	19.2
	Nov. 2	557	1671	1,770,000	512	7,590	4.54	27.2
	Nov. 4	554	1662	1,570,000	472	6,170	3.71	22.2
Waste - Main Screen Effluent	Nov.15	536	1608	1,620,000	402	5,420	3.37	20.2
	Nov.16	536	1608	1,520,000	420	5,330	3.32	19.9
	Nov.17	526	1578	1,580,000	473	6,140	3.89	23.3
	Nov.18	546	1638	1,460,000	475	5,800	3.54	21.2
	Average	541	1623	1,611,000	443	5,954	3.65	21.9
	Maximum	557	1671	1,760,000	512	7,590	4.54	27.2
	Minimum	526	1578	1,460,000	349	5,130	3.21	19.2

APPENDIX B - B.O.D. DATA, INCLUDING POPULATION EQUIVALENTS, FOR STRAIGHT HOUSE BEET SUGAR FACTORY WASTES
WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-NOVEMBER, 1949

SAMPLE	DATE 1949	BEETS PROCESSED: 8 AM-4 PM Shift Tons	BEETS PROCESSED: Per Day Tons	FLOW 8-Hr. Av. gpd	B. O. D.: ppm	B. O. D.: lb./day	B. O. D.: lb./ton	POPULATION EQUIVALENT Persons/Ton/Day
	Oct. 11	541	1623	553,000	595	2,740	1.69	10.1
Diffusion	Oct. 12	524	1572	562,000	675	3,170	2.01	12.0
	Oct. 13	532	1596	467,000	560	2,180	1.37	8.2
Battery	Oct. 14	547	1641	570,000	685	3,250	1.98	11.8
Waste -	Oct. 31	541	1623	641,000	555	2,970	1.83	11.0
	Nov. 1	532	1596	638,000	420	2,230	1.40	8.4
Relief	Nov. 2	557	1671	620,000	467	2,410	1.44	8.6
	Nov. 3	551	1653	623,000	442	2,300	1.39	8.3
Screen	Nov. 4	554	1662	669,000	606	3,390	2.04	12.2
Effluent	Nov. 14	565	1695	650,000	504	2,730	1.61	9.6
	Nov. 15	536	1608	700,000	382	2,230	1.39	8.3
	Nov. 16	536	1608	690,000	531	3,060	1.90	11.4
	Nov. 17	526	1578	690,000	582	3,340	2.12	12.7
	Nov. 18	546	1638	657,000	455	2,490	1.52	9.1
	Average	542	1626	623,600	533	2,749	1.69	10.1
	Maximum	565	1695	700,000	685	3,390	2.12	12.2
	Minimum	524	1572	467,000	382	2,180	1.39	8.2

APPENDIX B - B.O.D. DATA, INCLUDING POPULATION EQUIVALENTS, FOR STRAIGHT HOUSE BEET SUGAR FACTORY WASTES
WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-NOVEMBER, 1949

SAMPLE	DATE 1949	BEETS PROCESSED: 8 AM-4 PM Shift Tons	BEETS PROCESSED: Per Day Tons	FLOW: 8-Hr. Av. gpd	B. O. D.: mg/l	B. O. D.: lb./day	B. O. D.: lb./ton	POPULATION EQUIVALENT: Persons/Ton/Day
	Oct. 13	532	1596	62,700	12,000	6,270	3.93	23.5
	Oct. 14	547	1641	75,600	11,500	7,250	4.41	26.4
Filter								
	Oct. 31	541	1623	59,500	14,500	7,200	4.43	26.5
Cake	Nov. 1	532	1596	73,700	13,500	8,300	5.20	31.1
	Nov. 2	557	1671	67,900	11,200	7,450	4.45	27.2
Wastes	Nov. 4	554	1662	103,300	12,700	10,950	6.58	39.4
	Nov. 14	565	1695	67,200	7,700	4,310	2.54	15.2
	Nov. 15	536	1608	99,500	8,600	7,140	4.44	26.6
	Nov. 16	536	1608	51,700	9,600	4,140	2.55	15.3
	Nov. 17	526	1578	75,000	10,000	6,250	3.96	23.7
	Nov. 18	546	1638	107,200	8,400	7,500	4.58	27.4
	Average	543	1629	76,660	10,880	6,980	4.28	25.7
	Maximum	565	1695	107,200	14,500	10,950	6.58	39.4
	Minimum	526	1578	51,700	7,700	4,140	2.54	15.2

APPENDIX B – B.O.D. DATA, INCLUDING POPULATION EQUIVALENTS, FOR STRAIGHT HOUSE BEET SUGAR FACTORY WASTES
WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-NOVEMBER, 1949

SAMPLE	DATE 1949	BEETS PROCESSED: 8 AM–4 PM Shift Tons	BEETS PROCESSED: Per Day Tons	FLOW: 8-Hr. Av. gpd	B. O. D.: ppm	B. O. D.: lb./day	B. O. D.: lb./ton	POPULATION EQUIVALENT: Persons/Ton/Day
	Oct. 11	541	1623	488,000	3,440	14,100	8.7	52.1
Pulp	Oct. 12	524	1572	451,000	3,400	12,700	8.1	48.5
	Oct. 13	532	1596	440,000	4,280	15,700	9.8	58.7
Silo	Oct. 14	547	1641	415,000	5,080	17,600	10.7	64.0
Drainage	Oct. 31	541	1623	454,000	6,200	23,500	14.5	86.9
	Nov. 1	532	1596	481,000	6,290	25,200	15.8	94.6
	Nov. 2	557	1661	447,000	8,250	30,800	18.5	110.7
	Nov. 3	551	1653	415,000	5,880	20,400	12.7	76.0
	Nov. 4	554	1662	357,000	6,990	20,400	12.5	74.9
	Average	542	1626	439,000	5,534	20,040	12.37	74.1
	Maximum	557	1661	488,000	8,250	30,800	18.5	110.7
	Minimum	524	1572	357,000	3,440	12,700	8.1	48.5

APPENDIX B - B.O.D. DATA, INCLUDING POPULATION EQUIVALENTS, FOR STRAIGHT HOUSE BEET SUGAR FACTORY WASTES
WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-NOVEMBER, 1949

SAMPLE	DATE 1949	BEETS PROCESSED: 8 AM-4 PM Shift Tons	BEETS PROCESSED: Per Day Tons	FLOW: 8-Hr. Av. gpd	B. O. D.: ppm	B. O. D.: lb./day	B. O. D.: lb./ton	POPULATION EQUIVALENT: Persons/Ton/Day
	Oct. 11	541	1623	7,080,000	520	30,700	18.9	113
	Oct. 12	524	1572	7,070,000	473	27,900	17.7	106
	Oct. 13	532	1596	6,830,000	564	32,100	20.1	120
	Oct. 14	547	1641	6,630,000	524	29,000	17.6	105
Combined								
	Oct. 17	537	1611	6,770,000	627	36,000	22.3	134
Plant	Oct. 24	505	1515	6,200,000	1026	53,100	35.1	210
	Oct. 25	527	1581	6,220,000	555	28,900	18.9	113
Waste	Oct. 26	546	1638	6,320,000	558	29,500	18.0	108
	Oct. 27	546	1638	6,320,000	752	39,700	24.2	145
	Oct. 28	539	1617	6,960,000	627	36,400	22.5	135
	Oct. 31	541	1623	6,560,000	676	37,000	22.8	137
	Nov. 1	532	1596	6,530,000	668	36,400	22.8	137
	Nov. 2	557	1671	6,700,000	850	47,500	28.4	170
	Nov. 3	551	1653	6,800,000	619	35,100	21.2	127
	Nov. 4	554	1662	6,650,000	612	34,000	20.5	123
	Nov. 14	565	1695	6,360,000	617	32,800	19.4	116
	Nov. 15	556	1668	6,390,000	682	36,400	22.6	135
	Nov. 16	536	1608	6,350,000	678	35,900	22.3	133
	Nov. 17	526	1578	6,380,000	717	38,200	24.2	144
	Nov. 18	546	1638	6,380,000	687	36,500	22.3	133
	Average	539	1618	6,575,000	652	35,650	22.09	132
	Maximum	565	1695	7,080,000	1026	53,100	35.1	210
	Minimum	505	1515	6,200,000	473	27,900	17.6	105

APPENDIX C

SAMPLING DATA AND ANALYTICAL RESULTS FOR INFLUENTS AND EFFLUENTS TO LAGOONS RECEIVING SCREENED AND UNSCREENED FACTORY WASTE

APPENDIX C

SAMPLING DATA AND ANALYTICAL RESULTS FOR INFLUENTS AND EFFLUENTS TO LAGOONS RECEIVING SCREENED AND UNSCREENED FACTORY WASTES - WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY - OCTOBER-NOVEMBER, 1949

Sample	Date of Sampling 1949	Method of Collection and Compositing	Flow 8-Hr. Av. gpd	Temperature Max. °C	Temperature Av. °C	Temperature Min. °C	pH	Total Alkalinity $CaCO_3$ ppm	BOD 5-Day 20° C ppm	Total Solids Total ppm	Total Solids Suspended ppm	Total Solids Filtrable ppm	Volatile Solids Total ppm	Volatile Solids Suspended ppm	Volatile Solids Filtrable ppm	Nitrogen Organic ppm	Nitrogen NH_3 ppm
Unscreened Influent to Lagoon No.1	Oct. 24	8-Hour	372,000	24	26	27	6.4	222	692	4830	2940	1290	990	360	630	-	-
	Oct. 25		[illegible]	22	25	27	6.6	-	676	-	-	-	-	-	-	2.9	18.8
	Oct. 26	Composite	369,000	[illegible]	[illegible]	[illegible]	6.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	420	600	-	-
	Oct. 27		37[illegible]	[illegible]	[illegible]	[illegible]	6.3	-	691	-	-	-	-	-	-	4.7	17.6
	Oct. 28	Consisting	343,000	24	[illegible]	26	6.2	317	718	4760	3310	770	1[illegible]70	[illegible]40	[illegible]30	-	-
	Oct. 31	of 8 Equal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]69	[illegible]61	[illegible]930	[illegible]767	1265	111[illegible]	[illegible]5	665	-	-
	Nov. 2		324,000	23	[illegible]	27	[illegible].9	[illegible]65	789	[illegible]39[illegible]	[illegible]2[illegible]9	1410	1[illegible]30	[illegible]31	[illegible]99	[illegible].3	[illegible].7
	Nov. 4	Portions	324,[illegible]	[illegible]	[illegible]	27	[illegible].4	-	662	-	-	-	-	-	-	[illegible].[illegible]	-
	Nov. 8	Collected Hourly	323,000	22	24	26	[illegible].4	222	614	[illegible]96[illegible]	2190	170[illegible]	920	260	660	-	-
	No. of Determinations		9	-	9	-	9	6	9	6	6	6	6	6	6	4	3
	Average		349,900	-	[illegible]5	-	6.4	[illegible]92	658	[illegible]4[illegible]64	2670	[illegible]382	[illegible]124	412	612	[illegible].3	19.1
	Maximum		[illegible]7[illegible],000	-	[illegible]5	28	[illegible].6	[illegible]3[illegible]7	[illegible]88	[illegible]439[illegible]	[illegible]3[illegible]0	1785	1115	[illegible]30	[illegible]66	[illegible].5	-
	Minimum		324,[illegible]00	21	24	-	[illegible].9	[illegible]22	576	[illegible]3[illegible]0	2190	[illegible]0	920	[illegible]62	[illegible]23	[illegible].7	-
Effluent from Lagoon No.1	Oct. 24	8-Hour	24[illegible],[illegible]	16	19	[illegible]1	6.3	188	6[illegible]	1810	130	168[illegible]	[illegible]90	[illegible]7	[illegible]5	-	-
	Oct. 25		28[illegible],000	19	[illegible]0	21	[illegible].3	-	[illegible]67	-	-	-	-	-	-	[illegible].[illegible]	[illegible].8
	Oct. 26	Composite	[illegible]83,000	[illegible]2	[illegible]1	[illegible]3	[illegible].6	[illegible]96	[illegible]23	[illegible]7[illegible]1	13[illegible]	168	[illegible]3	[illegible]1	[illegible]7	-	-
	Oct. 27		294,000	19	20	21	[illegible].[illegible]	-	565	-	-	-	-	-	-	1.1	6.8
	Oct. 28	Consisting	298,000	19	21	21	[illegible].[illegible]	[illegible]17	547	168[illegible]	[illegible]9	1590	47[illegible]	[illegible]1	430	-	-
	Nov. 1	of 8 Equal	280,000	18	19	19	6.7	260	[illegible]97	1750	1[illegible]0	1650	470	[illegible]0	440	6.0	[illegible].[illegible]
	Nov. 3	Portions	309,000	1[illegible]	[illegible]0	[illegible]1	6.4	228	661	1700	[illegible]0	1630	440	[illegible]0	420	[illegible].3	[illegible].5
	Nov. 7	Collected Hourly	282,000	19	[illegible]	21	[illegible].[illegible]	240	643	1760	110	1650	450	[illegible]0	420	0.9	9.2
	No. of Determinations		8	-	8	-	8	6	8	6	6	6	6	6	6	5	5
	Average		283,300	-	20	-	[illegible].5	[illegible]30	[illegible]8[illegible]	1735	1[illegible]5	1630	492	35	457	[illegible].1	[illegible].7
	Maximum		309,000	-	21	22	[illegible].7	260	661	1810	130	1680	[illegible]90	[illegible]0	560	[illegible].0	9.2
	Minimum		240,000	16	19	-	[illegible].3	[illegible]8[illegible]	[illegible]23	1680	[illegible]0	1580	440	[illegible]0	420	[illegible].3	[illegible].2

APPENDIX C

SAMPLING DATA AND ANALYTICAL RESULTS FOR INFLUENTS AND EFFLUENTS TO LAGOONS RECEIVING SCREENED AND UNSCREENED FACTORY WASTES - WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY - OCTOBER-NOVEMBER, 1949

Sample	Date of Sampling 1949	Method of Collection and Compositing	Flow 8-Hr. Av. gpd	Temperature			pH	Total Alkalinity $CaCO_3$ ppm	BOD 5-Day 20° C ppm	Total Solids			Volatile Solids			Nitrogen	
				Max. °C	Av. °C	Min. °C				Total ppm	Suspended ppm	Filtrable ppm	Total ppm	Suspended ppm	Filtrable ppm	NH_3 ppm	Organic ppm
Screened	Oct. 24	8-Hour	336,000	14	23	27	6.5	224	690	4250	3390	860	900	380	520	-	-
	Oct. 25		317,000	23	24	27	6.7	-	566	-	-	-	-	-	-	2.6	15.3
Influent	Oct. 26	Composite	317,000	23	26	28	6.5	200	577	4100	2880	1220	960	370	590	-	-
	Oct. 27		329,000	24	26	27	6.3	-	609	-	-	-	-	-	-	2.9	20.1
to Lagoon	Oct. 28	Consisting	323,000	24	25	27	6.8	292	717	4070	2740	1330	1120	340	780	-	-
No. 2	Oct. 31	of 8	317,000	21	24	26	6.8	310	631	3910	2720	1190	1000	360	640	-	-
	Nov. 2		297,000	23	25	27	6.9	227	792	3810	2340	1460	990	280	710	3.3	21.5
	Nov. 4	Equal	317,000	22	25	27	6.4	-	618	-	-	-	-	-	-	4.7	15.5
	Nov. 8	Portions	323,000	22	23	25	6.4	220	614	3520	2010	1510	880	290	590	-	-
		Collected															
		Hourly															
	No. of Determinations		9	-	9	-	9	6	9	6	6	6	6	6	6	4	4
	Average		319,600	-	24	-	6.5	246	646	3943	2681	1262	975	337	638	3.4	18.1
	Maximum		336,000	-	26	28	6.9	310	792	4250	3390	1510	1120	380	780	4.7	21.5
	Minimum		297,000	14	23	-	6.3	200	566	3520	2010	860	880	280	520	2.6	15.3
Effluent	Oct. 24	8-Hour	-	16	18	20	6.7	188	545	1920	130	1790	630	40	590	-	-
	Oct. 25		132,000	19	20	21	6.7	-	511	-	-	-	-	-	-	1.2	9.3
From	Oct. 26	Composite	141,000	20	21	21	6.7	198	496	1780	110	1670	550	30	520	-	-
	Oct. 27	Consisting	149,000	19	20	21	6.6	-	517	-	-	-	-	-	-	1.4	6.8
Lagoon	Oct. 28	of 8	159,000	19	20	21	6.4	218	531	1740	70	1670	510	40	470	-	-
No.2	Nov. 1	Equal	157,000	18	19	20	6.7	266	532	1750	60	1690	500	30	470	0.7	7.1
	Nov. 3	Portions	171,000	-	21	-	6.6	229	617	1660	50	1610	420	10	410	0.4	8.2
	Nov. 7	Collected Hourly	166,000	19	20	20	6.4	238	642	1660	70	1590	440	20	420	0.9	8.1
	No. of Determinations		7	-	8	-	8	6	8	6	6	6	6	6	6	5	5
	Average		154,300	-	20	-	6.6	224	548	1752	82	1670	508	28	480	0.9	7.9
	Maximum		171,000	-	21	21	6.7	266	642	1920	130	1790	630	40	590	1.4	9.3
	Minimum		132,000	16	18	-	6.4	188	496	1660	50	1610	420	10	410	0.4	6.8

APPENDIX D

SAMPLING DATA AND ANALYTICAL DATA FOR INFLUENTS AND EFFLUENTS FROM LAGOONS RECEIVING WASTES TREATED WITH NITRATE OR PHOSPHATE

APPENDIX D

SAMPLING DATA AND ANALYTICAL RESULTS FOR INFLUENTS AND EFFLUENTS FROM LAGOONS RECEIVING WASTES TREATED WITH NITRATE OR PHOSPHATE - WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, NOVEMBER-DECEMBER, 1949

Determination	Date	Influent to Each Lagoon	EFFLUENT: Lagoon No.1 (NH_4NO_3) (Treated)	EFFLUENT: Lagoon No.2 ($(NH_4)_3PO_4$) (Treated)	EFFLUENT: Lagoon No.3 (Control)
Flow in gpd	Nov. 20	258,000	-	-	-
	Nov. 21	258,000	-	-	-
	Nov. 22	129,000	160,000	55,000	56,600
	Nov. 23	129,000	-	-	-
	Nov. 24	129,000	102,000	105,000	67,900
	Nov. 25	129,000	97,000	69,800	64,000
	Nov. 26	116,000	-	-	-
	Nov. 27	129,000	105,000	83,500	76,300
	Nov. 28	129,000	105,000	105,000	76,300
	Nov. 29	78,000	-	-	-
	Nov. 30	[illegible]	112,000	83,500	72,500
	Dec. 1	129,000	-	-	-
	Dec. 2	129,000	-	-	-
	Dec. 3	129,000	-	-	-
	Dec. 4	129,000	133,000	105,000	67,200
	Dec. 5	129,000	-	-	-
	Dec. 6	129,000	125,000	97,600	73,100
	Dec. 7	129,000	122,000	102,000	72,300
	Average	139,800	117,900	89,600	70,700
Temperature Av. of 3 Readings in °C.	Nov. 21	22	-	-	-
	Nov. 22	21	14	14	15
	Nov. 24	22	12	13	12
	Nov. 25	24	13	13	13
	Nov. 27	23	12	13	13
	Nov. 28	23	12	13	12
	Nov. 30	22	11	11	11
	Dec. 1	21	-	-	-
	Dec. 4	20	11	10	10
	Dec. 5	20	-	-	-
	Dec. 6	20	10	10	9
	Dec. 7	20	10	10	10
	Average	21	12	12	12

APPENDIX D

SAMPLING DATA AND ANALYTICAL RESULTS FOR INFLUENTS AND EFFLUENTS FROM LAGOONS RECEIVING WASTES TREATED WITH NITRATE OR PHOSPHATE - WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, NOVEMBER-DECEMBER, 1949

Determination	Date	Influent to Each Lagoon	EFFLUENT: Lagoon No.1 (NH_4NO_3) (Treated)	EFFLUENT: Lagoon No.2 ($(NH_4)_3PO_4$) (Treated)	EFFLUENT: Lagoon No.3 (Control)
pH	Nov. 21	7.0	-	-	-
	Nov. 22	6.9	5.7	5.5	6.3
	Nov. 24	6.5	5.5	5.6	6.0
	Nov. 25	6.3	5.3	5.4	5.7
	Nov. 27	6.7	-	-	-
	Nov. 28	6.8	5.5	5.6	5.9
	Nov. 30	7.1	5.9	5.8	6.0
	Dec. 1	7.2	-	-	-
	Dec. 4	7.0	6.6	6.6	6.6
	Dec. 5	7.2	-	-	-
	Dec. 6	-	-	-	-
	Dec. 7	7.4	6.8	6.7	6.8
	Average	6.9	5.9	5.9	6.2
Total Alkalinity As $CaCO_3$ in ppm	Nov. 24	236	249	229	255
	Nov. 28	274	253	273	306
	Average	255	251	251	280
B.O.D. 5-Day 20°C. in ppm	Nov. 21	749	-	-	-
	Nov. 22	784	704	662	555
	Nov. 24	734	695	620	571
	Nov. 25	771	651	608	570
	Nov. 27	638	-	-	-
	Nov. 28	674	658	602	603
	Nov. 30	656	610	585	585
	Dec. 1	794	-	-	-
	Dec. 4	760	657	605	616
	Dec. 5	837	-	-	-
	Dec. 7	928	630	576	646
	Average	757	659	608	592

APPENDIX D

SAMPLING DATA AND ANALYTICAL RESULTS FOR INFLUENTS AND EFFLUENTS FROM LAGOONS RECEIVING WASTES TREATED WITH NITRATE OR PHOSPHATE - WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, NOVEMBER-DECEMBER, 1949

Determination	Date	Influent to Each Lagoon	EFFLUENT		
			Lagoon No.1 (NH_4NO_3) (Treated)	Lagoon No.2 ($(NH_4)_3PO_4$) (Treated)	Lagoon No.3 (Control)
Phosphorus in ppm	Nov. 24	0.2	0.1	4.5	0.0
	Nov. 25	0.4	0.1	5.0	0.0
	Nov. 28	0.4	0.1	6.0	0.0
	Nov. 30	0.2	0.0	10.0	0.0
	Dec. 1	0.3	0.0	11.0	0.4
	Dec. 7	0.1	0.0	8.0	0.2
	Average	0.3	0.05	7.9	0.10
Organic Nitrogen in ppm	Nov. 28	21.4	10.2	7.5	9.5
	Dec. 4	22.3	2.9	10.0	8.1
	Dec. 7	27.6	12.6	9.1	7.9
	Average	23.8	8.6	8.9	8.5
Ammonia Nitrogen in ppm	Nov. 21	4.0	-	-	-
	Nov. 22	3.8	14.0	13.5	1.5
	Nov. 24	3.7	11.5	13.5	1.2
	Nov. 25	4.5	11.5	12.5	1.2
	Nov. 27	3.8	-	-	-
	Nov. 28	4.5	14.0	16.0	1.0
	Nov. 30	3.8	15.0	16.0	1.0
	Dec. 4	4.6	17.5	16.5	1.0
	Dec. 7	4.6	16.0	16.0	1.2
	Average	4.1	14.2	14.9	1.1

APPENDIX D

SAMPLING DATA AND ANALYTICAL RESULTS FOR INFLUENTS AND EFFLUENTS FROM LAGOONS RECEIVING WASTES TREATED WITH NITRATE OR PHOSPHATE - WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, NOVEMBER-DECEMBER, 1949

Determination	Date	Influent to Each Lagoon	Effluent: Lagoon No. 1 (NH_4NO_3) (Treated)	Effluent: Lagoon No. 2 ($(NH_4)_3PO_4$) (Treated)	Effluent: Lagoon No. 3 (Control)
Nitrite Nitrogen in ppm	Nov. 24	0.1	0.8	0.0	0.0
	Nov. 25	0.1	2.0	0.0	0.0
	Nov. 27	0.1	-	-	-
	Nov. 28	0.1	4.0	0.0	0.0
	Nov. 30	0.2	6.0	0.1	0.0
	Dec. 4	0.4	5.8	0.2	0.0
	Dec. 7	0.9	11.0	0.0	0.0
	Average	0.3	4.9	0.0	0.0
Nitrate Nitrogen in ppm	Nov. 21	0.4	-	-	-
	Nov. 22	-	8.0	0.2	0.0
	Nov. 23	0.1	-	-	-
	Nov. 24	0.1	10.0	0.0	0.0
	Nov. 25	-	10.0	0.1	0.0
	Nov. 27	0.5	-	-	-
	Nov. 28	0.6	14.0	0.1	0.1
	Nov. 30	0.2	12.0	0.1	0.0
	Dec. 4	0.1	14.0	0.4	0.0
	Dec. 7	0.8	9.0	0.1	0.1
	Average	0.4	9.8	0.1	0.0

APPENDIX E

SAMPLING DATA AND ANALYTICAL RESULTS FOR CACHE LA POUDRE RIVER NEAR NEOR, COLORADO

APPENDIX E - SAMPLING DATA AND ANALYTICAL RESULTS FOR CACHE LA POUDRE RIVER NEAR WINDSOR, COLORADO
WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-DECEMBER, 1949

Sample	Date	Time	Staff Gage Reading Ft.	Flow cfs	Temp. °C.	pH	Total Alkalinity $CaCO_3$ ppm	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	B.O.D. ppm
	Oct. 10	9:00 AM	3.62	7.8	11 1/2	8.2	284	10.4	95	2.9
	Oct. 11	9:40 AM	3.62	7.8	9	8.1	294	10.6	92	2.3
Cache	Oct. 12	8:25 AM	3.62	7.8	7	8.1	300	10.3	85	2.0
La Poudre	Oct. 13	8:20 AM	3.60	7.5	9	8.2	297	10.2	88	1.7
River	Oct. 14	8:20 AM	3.60	7.5	9	8.2	298	10.2	88	1.5
(Mile 21.8) at County Highway	Oct. 28	8:15 AM	3.68	8.8	6 1/2	8.0	-	9.3	75	4.0
Bridge	Nov. 7	8:20 AM	3.62	7.8	4	8.1	302	10.2	78	2.4
	Nov. 9	-	-		-	8.1	298	9.8	-	2.8
	Nov. 14	8:10 AM	3.64	8.2	4 1/2	8.0	282	10.3	80	2.4
	Nov. 21	8:25 AM	3.64	8.2	1	8.0	-	11.2	79	1.5
	Average		3.63	7.9		8.1	294	10.2	84	2.4

APPENDIX E - SAMPLING DATA AND ANALYTICAL RESULTS FOR CACHE LA POUDRE RIVER NEAR WINDSOR, COLORADO
WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-DECEMBER, 1949

Sample	Date	Time	Staff Gage Reading Feet	Flow cfs	Temp. °C.	pH	Total Alkalinity $CaCO_3$ ppm	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	B.O.D. ppm
Cache La Poudre River (Mile 21.3) at Ford on G.W.Sugar Company Farm	Oct. 24	8:35 AM	3.62	7.8	8 1/2	7.8	300	7.0	60	4.5
	Oct. 25	8:35 AM	3.62	7.8	7 1/2	7.8	288	7.1	59	3.8
	Oct. 26	8:40 AM	3.64	8.2	7 1/2	7.9	-	6.9	57	2.8
	Oct. 27	8:10 AM	3.62	7.8	8 1/2	7.8	290	6.3	54	3.4
	Oct. 28	8:25 AM	3.68	8.8	7 1/2	7.9	-	7.2	60	4.0
	Nov. 7	8:30 AM	3.62	7.8	5	7.8	288	7.5	59	2.7
	Nov. 9	-	-	-	-	7.9	290	7.9	-	3.4
	Nov. 14	8:20 AM	3.64	8.2	6	7.9	296	8.4	67	2.5
	Nov. 16	8:30 AM	3.64	8.2	6	7.9	276	7.6	61	2.0
	Nov. 18	8:10 AM	3.64	8.2	5 1/2	7.9	290	7.7	61	2.6
	Nov. 21	8:35 AM	3.64	8.2	3	8.2	-	8.6	64	1.8
	Nov. 23	8:10 AM	3.61	7.7	1 1/2	7.9	-	8.5	60	2.4
	Nov. 25	7:45 AM	3.58	7.2	4 1/2	8.0	302	7.1	55	2.4
	Dec. 5	8:55 AM	3.60	7.5	2 1/2	8.1	-	9.7	71	3.0
	Average		3.63	8.0		7.9	291	7.7	61	3.0

APPENDIX E - SAMPLING DATA AND ANALYTICAL RESULTS FOR CACHE LA POUDRE RIVER NEAR WINDSOR, COLORADO
WINDSOR FACTORY, GREAT WESTERN SUGAR COMPANY, OCTOBER-DECEMBER, 1949

Sample	Date	Time	Staff Gage Reading Feet	Flow cfs	Temp. °C.	pH	Total Alkalinity $CaCO_3$ ppm	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	B.O.D. ppm
	Oct. 10	9:10 AM	0.48	8.0	11 1/2	7.6	319	2.9	26	69
	Oct. 11	9:50 AM	0.52	9.3	9 1/2	7.5	322	2.4	21	120
Cache La	Oct. 12	8:35 AM	0.54	9.9	10	7.2	332	1.5	13	141
Poudre River	Oct. 13	8:30 AM	0.54	9.9	11 1/2	7.4	330	1.2	11	153
(Mile 20.0)	Oct. 14	8:30 AM	0.52	9.3	11 1/2	7.3	337	0.9	8	165
at State										
Highway No. 257	Oct. 24	8:45 AM	0.50	8.6	10	7.2	375	1.5	13	271
Bridge	Oct. 25	8:45 AM	0.54	9.9	9 1/2	7.2	362	1.5	13	255
	Oct. 26	8:40 AM	0.54	9.9	10	7.2	-	0.9	8	250
	Oct. 27	8:20 AM	0.54	9.9	10 1/2	7.2	363	0.7	6	292
	Oct. 28	8:35 AM	0.60	11.9	10	7.2	-	1.2	11	259
	Nov. 7	8:40 AM	0.54	9.9	8 1/2	7.2	388	0.9	8	537
	Nov. 9	8:25 AM	0.55	10.3	-	7.4	388	0.4	-	269
	Nov. 14	8:30 AM	0.56	10.6	8 1/2	7.2	386	0.9	8	285
	Nov. 16	8:25 AM	0.60	11.9	9	7.1	386	0.0	0	250
	Nov. 18	8:20 AM	0.58	11.2	7 1/2	7.2	438	0.0	0	258
	Nov. 21	8:40 AM	0.60	11.9	5	7.5	-	0.0	0	320
	Nov. 23	8:20 AM	0.62	12.6	4 1/2	7.3	-	0.0	0	269
	Nov. 25	8:30 AM	0.64	13.3	7 1/2	7.4	432	-	-	252
	Dec. 5	9:05 AM	0.66	14.0	4 1/2	7.4	-	0.0	0	333
	Average		0.56	10.6		7.3	368	0.9	[illegible]	250